IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

SAMSUNG ELECTRONICS CO., LTD., Plaintiff, v. SHARP CORPORATION; SHARP ELECTRONICS CORPORATION; AND SHARP ELECTRONICS MANUFACTURING COMPANY OF AMERICA, INC. Defendants.	Civil Action No. ____________________ **JURY TRIAL DEMANDED**

COMPLAINT

Plaintiff Samsung Electronics Co., Ltd. ("Samsung"), by and through the undersigned attorneys, hereby brings this Complaint against Sharp Corporation; Sharp Electronics Corporation; and Sharp Electronics Manufacturing Company of America, Inc. (collectively "the Sharp Defendants"), and alleges as follows:

PARTIES

1. Samsung Electronics Co., Ltd., is a limited liability corporation organized under the laws of Korea, with its principal place of business at 416 Maetan-dong, Youngtong-gu, Suwon, Kyunggi-Do, 443-742, Korea. Samsung is a world leader in the design, innovation, manufacture and marketing of a wide variety of electronic products, including devices employing the liquid crystal display ("LCD") technology that is at the heart of this action.

2. On information and belief, defendant Sharp Corporation ("Sharp Corp.") is a Japanese corporation with its principal place of business at 22-22 Nagaike-cho, Abeno-ku, Osaka 545-8522, Japan.

3. On information and belief, defendant Sharp Electronics Corporation ("Sharp USA") is a corporation organized and existing under the laws of New York, with its principal place of business at 1 Sharp Plaza, Mahwah, New Jersey 07430-2135.

4. On information and belief, defendant Sharp Electronics Manufacturing Company of America, Inc. ("SEMA") is a corporation organized under the laws of California with its principal place of business at 9295 Siempre Viva Road, Suite J2, San Diego, California 92154.

JURISDICTION AND VENUE

5. This Court has subject matter jurisdiction over this action pursuant to 28 U.S.C. §§ 1331 and 1338(a) because the action concerns a federal question relating to patents arising under Title 35 of the United States Code, including 35 U.S.C. § 271.

6. This Court has personal jurisdiction over the Sharp Defendants at least because they do business in the State of Delaware, and infringement has occurred and continues to occur in this state and this district.

7. Venue is proper in the District of Delaware pursuant to 28 U.S.C. §§ 1391(b), (c), and (d) and 1400(b), because the Sharp Defendants do business in the State of Delaware, and have committed acts of infringement in this State and this District; because the Sharp Defendants are subject to personal jurisdiction in this Court; and because Sharp Corp. is an alien that may be sued in any district.

COUNT ONE
(Infringement of U.S. Patent No. 7,193,666)

8. Samsung incorporates by reference the allegations of paragraphs 1 through 7 of this Complaint as though fully set forth herein.

9. Samsung is the owner of all rights, title, and interest in U.S. Patent No. 7,193,666 ("the '666 patent"), entitled "Dual Liquid Crystal Display Device," which was duly and properly

issued by the United States Patent and Trademark Office ("USPTO") on March 20, 2007. A copy of the '666 patent is attached as Exhibit 1.

10. In violation of 35 U.S.C. § 271, the Sharp Defendants are and have been directly infringing, contributing to the infringement of, and/or inducing others to infringe the '666 patent by making, using, selling, and/or offering to sell in the United States, or importing into the United States, products or processes that practice inventions claimed in the '666 patent.

11. As a result of the Sharp Defendants' unlawful infringement of the '666 patent, Samsung has suffered and will continue to suffer damage. Samsung is entitled to recover from the Sharp Defendants the damages suffered by Samsung as a result of their unlawful acts.

12. On information and belief, the Sharp Defendants intend to continue their unlawful infringing activity, and Samsung continues to and will continue to suffer irreparable harm – for which there is no adequate remedy at law – from such unlawful infringing activities unless this Court enjoins the Sharp Defendants from further infringing activities.

COUNT TWO
(Infringement of U.S. Patent No. 6,771,344)

13. Samsung incorporates by reference the allegations of paragraphs 1 through 12 of this Complaint as though fully set forth herein.

14. Samsung is the owner of all rights, title, and interest in U.S. Patent No. 6,771,344 ("the '344 patent"), entitled "Liquid Crystal Display Having Wide Viewing Angle," which was duly and properly issued by the USPTO on August 3, 2004. A copy of the '344 patent is attached as Exhibit 2.

15. In violation of 35 U.S.C. § 271, the Sharp Defendants are and have been directly infringing, contributing to the infringement of, and/or inducing others to infringe the '344 patent

by making, using, selling, and/or offering to sell in the United States, or importing into the United States, products or processes that practice inventions claimed in the '344 patent.

16. As a result of the Sharp Defendants' unlawful infringement of the '344 patent, Samsung has suffered and will continue to suffer damage. Samsung is entitled to recover from the Sharp Defendants the damages suffered by Samsung as a result of their unlawful acts.

17. On information and belief, the Sharp Defendants intend to continue their unlawful infringing activity, and Samsung continues to and will continue to suffer irreparable harm – for which there is no adequate remedy at law – from such unlawful infringing activities unless this Court enjoins the Sharp Defendants from further infringing activities.

COUNT THREE
(Infringement of U.S. Patent No. 7,295,196)

18. Samsung incorporates by reference the allegations of paragraphs 1 through 17 of this Complaint as though fully set forth herein.

19. Samsung is the owner of all rights, title, and interest in U.S. Patent No. 7,295,196 ("the '196 patent"), entitled "Liquid Crystal Display Panel With Signal Transmission Patterns" and issued on November 13, 2007. A copy of the '196 patent is attached as Exhibit 3.

20. In violation of 35 U.S.C. § 271, the Sharp Defendants are and have been directly infringing, contributing to the infringement of, and/or inducing others to infringe the '196 patent by making, using, selling, and/or offering to sell in the United States, or importing into the United States, products or processes that practice inventions claimed in the '196 patent.

21. As a result of the Sharp Defendants' unlawful infringement of the '196 patent, Samsung has suffered and will continue to suffer damage. Samsung is entitled to recover from the Sharp Defendants the damages suffered by Samsung as a result of their unlawful acts.

22. On information and belief, the Sharp Defendants intend to continue their unlawful infringing activity, and Samsung continues to and will continue to suffer irreparable harm – for which there is no adequate remedy at law – from such unlawful infringing activities unless this Court enjoins the Sharp Defendants from further infringing activities.

COUNT FOUR
(Infringement of U.S. Patent No. 6,937,311)

23. Samsung incorporates by reference the allegations of paragraphs 1 through 22 of this Complaint as though fully set forth herein.

24. Samsung is the owner of all rights, title, and interest in U.S. Patent No. 6,937,311 ("the '311 patent"), entitled "Liquid Crystal Display Having Domain Dividers" and issued on August 30, 2005. A copy of the '311 patent is attached as Exhibit 4.

25. In violation of 35 U.S.C. § 271, the Sharp Defendants are and have been directly infringing, contributing to the infringement of, and/or inducing others to infringe the '311 patent by making, using, selling, and/or offering to sell in the United States, or importing into the United States, products or processes that practice inventions claimed in the '311 patent.

26. As a result of the Sharp Defendants' unlawful infringement of the '311 patent, Samsung has suffered and will continue to suffer damage. Samsung is entitled to recover from the Sharp Defendants the damages suffered by Samsung as a result of their unlawful acts.

27. On information and belief, the Sharp Defendants intend to continue their unlawful infringing activity, and Samsung continues to and will continue to suffer irreparable harm – for which there is no adequate remedy at law – from such unlawful infringing activities unless this Court enjoins the Sharp Defendants from further infringing activities.

PRAYER FOR RELIEF

WHEREFORE, Samsung prays that this Honorable Court enters an Order and Judgment:

a. Finding in favor of Samsung and against the Sharp Defendants on all counts asserted in this Complaint;

b. Adjudging that the Sharp Defendants have infringed each of the ’666, ’344, ’196, and ’311 patents (collectively, “the patents-in-suit”);

c. Permanently enjoining the Sharp Defendants and their respective officers, agents, servants, employees, attorneys, and all persons in active concert or participation with any of them, from further infringement of the patents-in-suit;

d. Awarding Samsung damages and an accounting in an amount adequate to compensate Samsung for the Sharp Defendants’ infringement, along with pre-judgment and post-judgment interest and costs at the highest rate allowable by law, pursuant to 35 U.S.C. § 284;

e. Declaring this case “exceptional” under 35 U.S.C. § 285 and awarding Samsung its attorneys’ fees, expenses and costs incurred in this action; and

f. Granting Samsung such other and further equitable or legal relief as this Court deems just and proper.

DEMAND FOR JURY TRIAL

Plaintiff Samsung hereby demands a jury trial on all issues so triable.

Dated: December 21, 2007

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By: ______________________________

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Samsung Electronics Co., Ltd.

Exhibit 1

US007193666B2

(12) **United States Patent**
Choi et al.

(10) **Patent No.: US 7,193,666 B2**
(45) **Date of Patent: *Mar. 20, 2007**

(54) **DUAL LIQUID CRYSTAL DISPLAY DEVICE**

(75) Inventors: **Jung-Min Choi**, Suwon-si (KR); **Dong-Ho Lee**, Yongin-si (KR)

(73) Assignee: **Samsung Electronics Co, Ltd.** (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/980,656**

(22) Filed: **Nov. 3, 2004**

(65) **Prior Publication Data**

US 2005/0062913 A1 Mar. 24, 2005

Related U.S. Application Data

(63) Continuation of application No. 10/454,700, filed on Jun. 3, 2003, now Pat. No. 6,831,711.

(30) **Foreign Application Priority Data**

Jul. 26, 2002 (KR) 2002-44264

(51) **Int. Cl.**
G02F 1/1347 (2006.01)

(52) **U.S. Cl.** **349/74**; 349/114; 349/62; 349/61

(58) **Field of Classification Search** 349/61, 349/62, 65, 73, 74, 113, 114
See application file for complete search history.

(56) **References Cited**

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PCT Notification of Transmittal of the International Search Report of the Declaration; International Application No. PCT/KR03/01045; International filing date of May 28, 2003; Mailing date of Sep. 25, 2003.

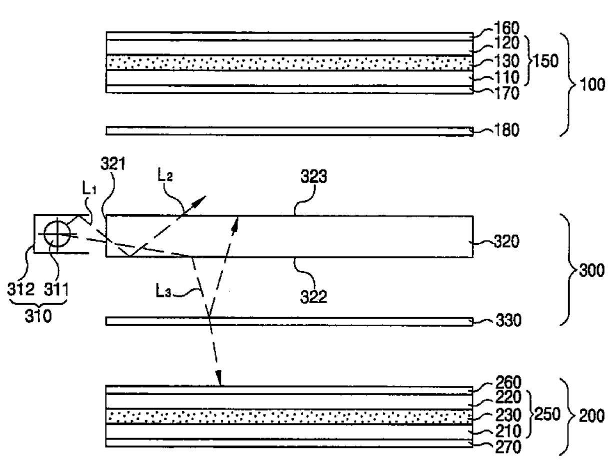
Primary Examiner—Andrew Schechter
Assistant Examiner—Richard H Kim
(74) *Attorney, Agent, or Firm*—Cantor Colburn LLP

(57) **ABSTRACT**

Disclosed is an LCD device for performing bi-directional display. The LCD device includes first and second display units, and a light supplying unit. The first display unit includes an LCD panel and a transflective film that is disposed under the LCD panel and has layers in which first and second layers having different refractivity indexes are alternately stacked. The transflective film partially reflects and transmits light incident onto the film. The light supplying unit is disposed between the first and second display units, and provide the first and second display units with light generated from a lamp by dividing the light, to thereby regulate a contrast ratio of a luminance between the first and second display units. Therefore, the structure of an LCD panel for performing bi-directional image display can be simplified, and the light loss in the transmission mode can be reduced.

23 Claims, 20 Drawing Sheets

400



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6,847,427	B2 *	1/2005	Yamauchi	349/113

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WO	97/01788	1/1997

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FIG.1

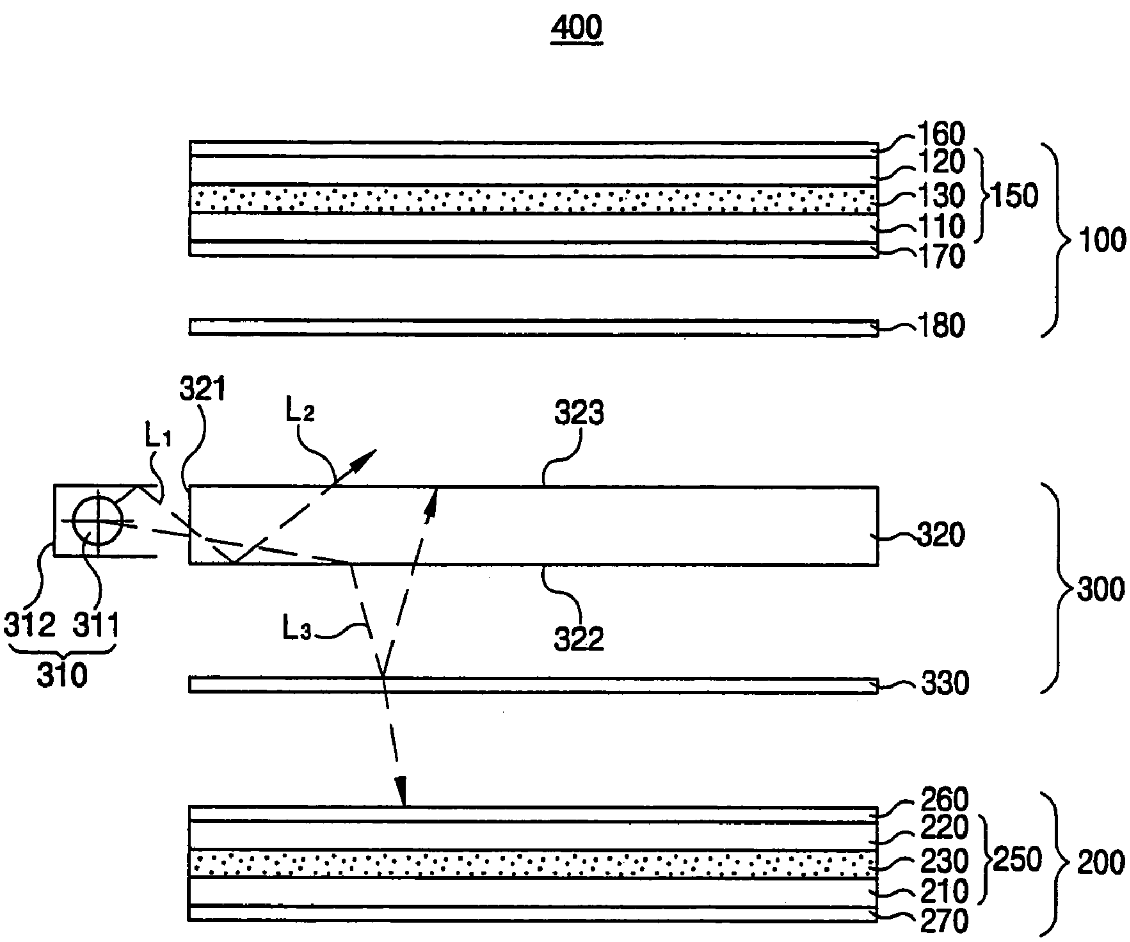
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FIG.2

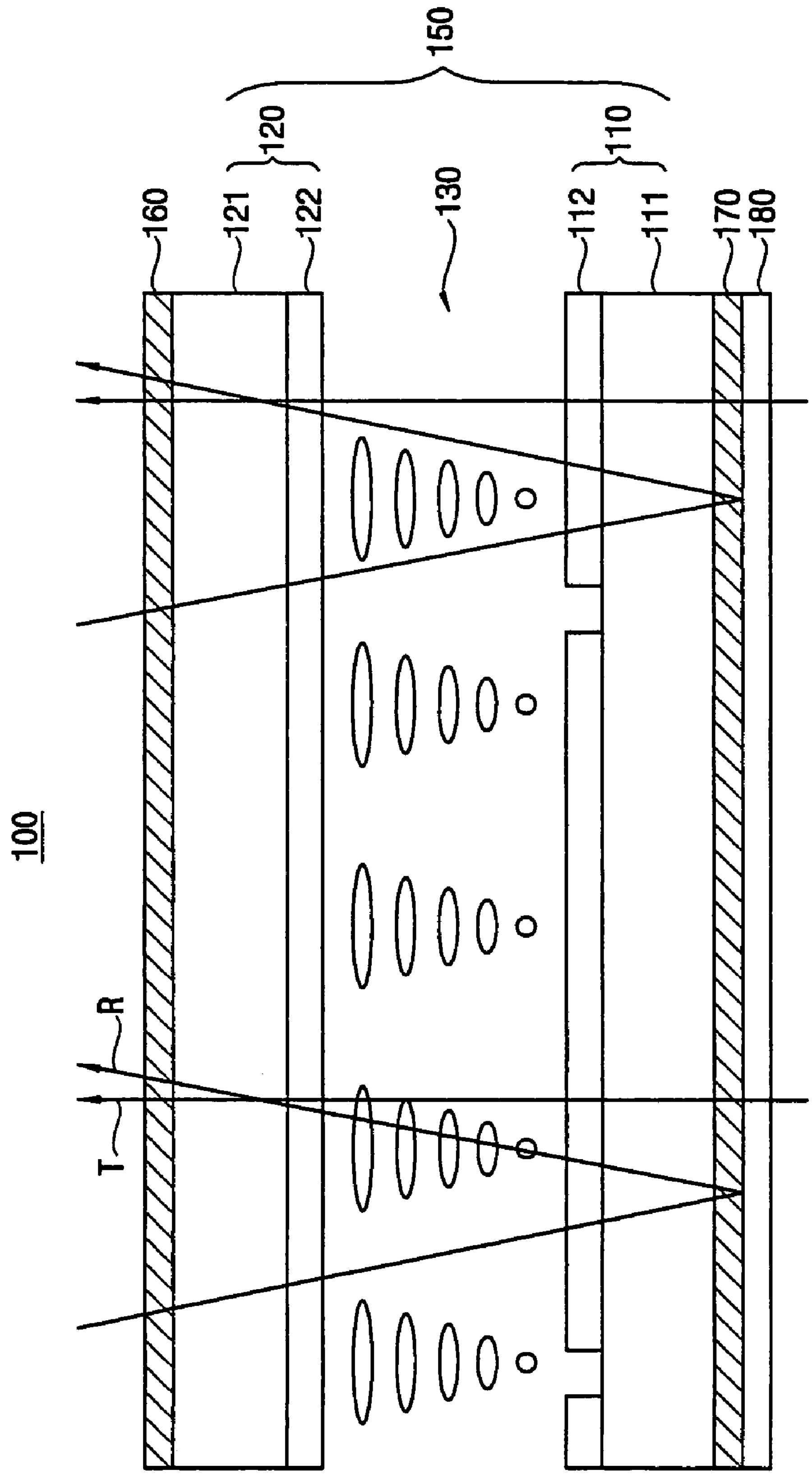

FIG.3

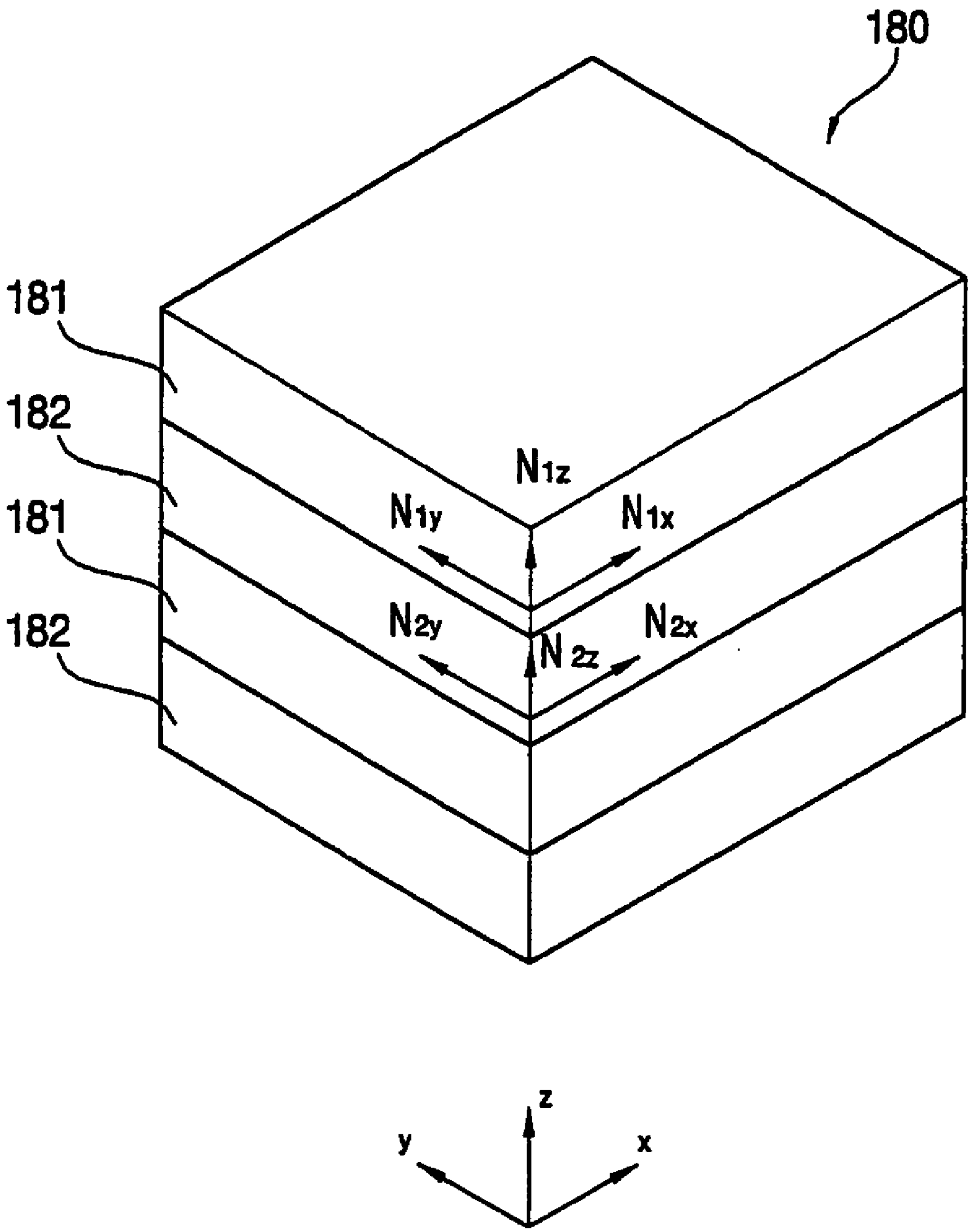

FIG.4A

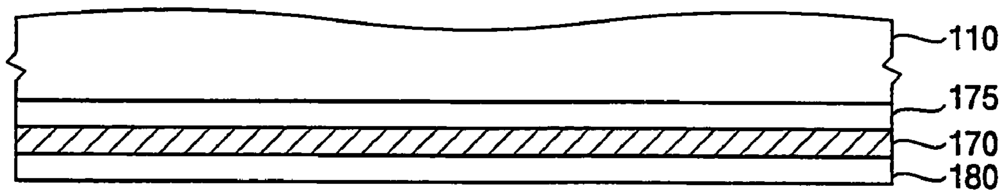

FIG.4B

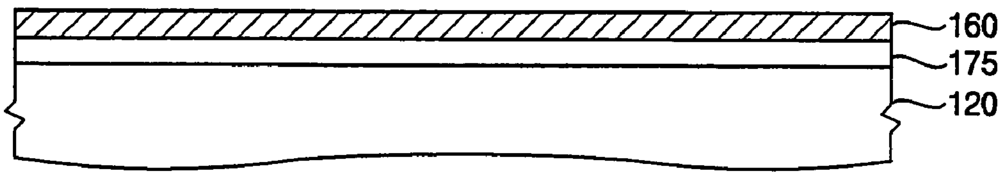

FIG.4C

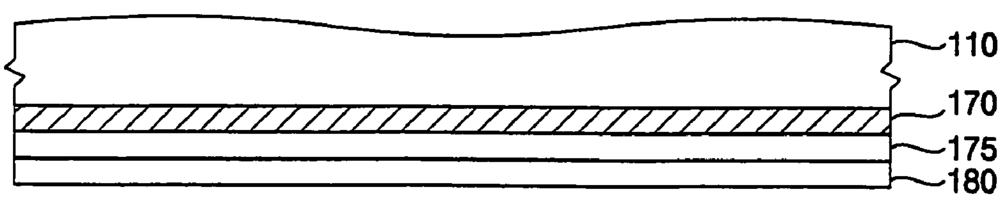

FIG.5A

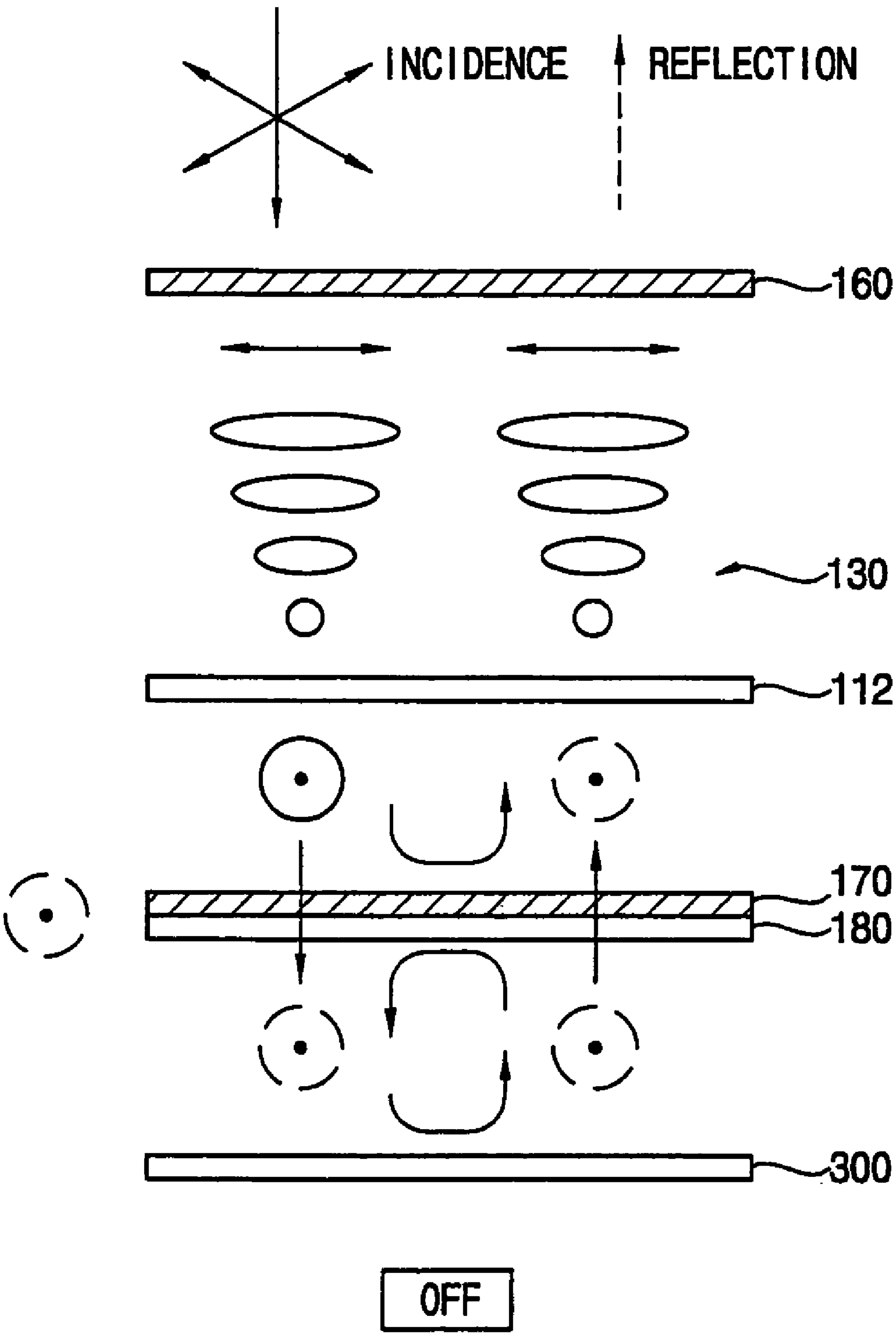

FIG.5B

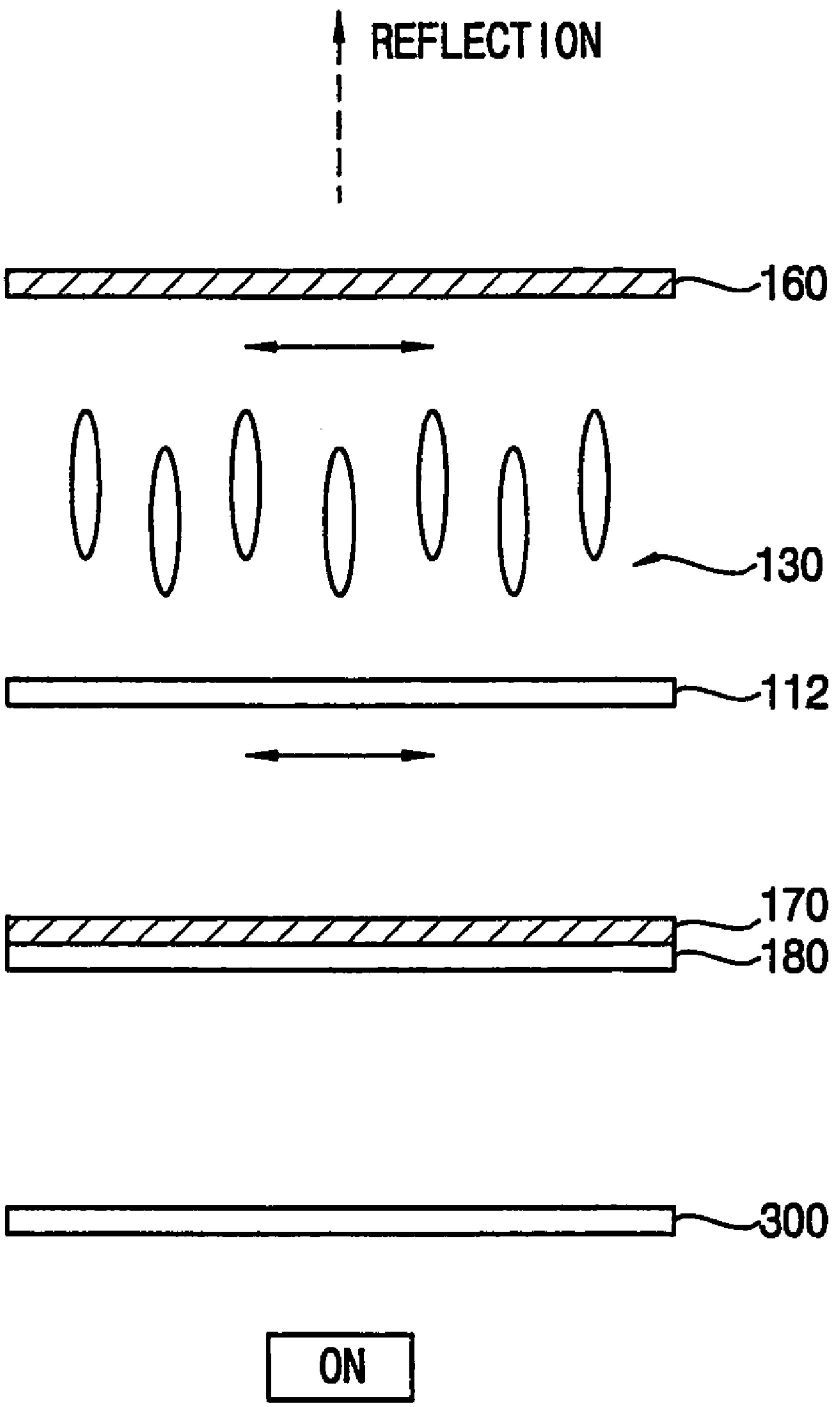

FIG.6A

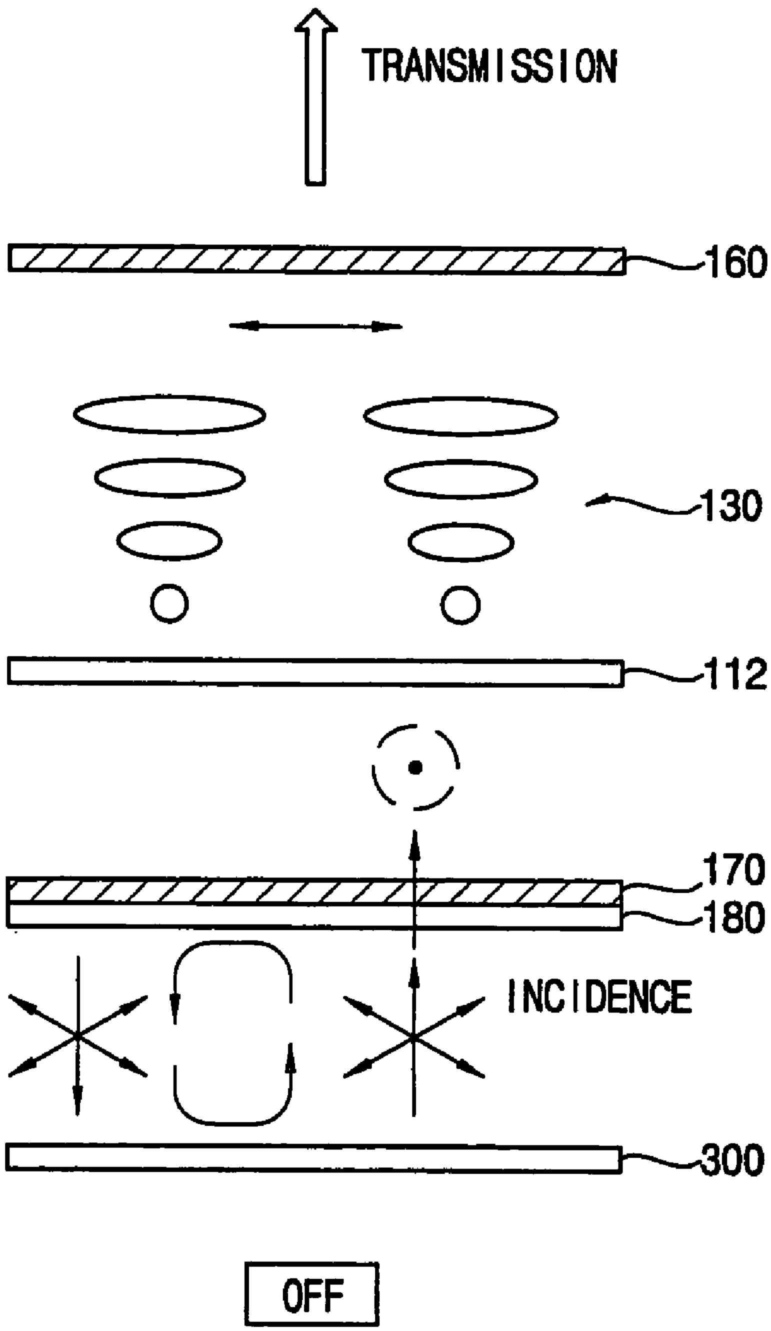

FIG.6B

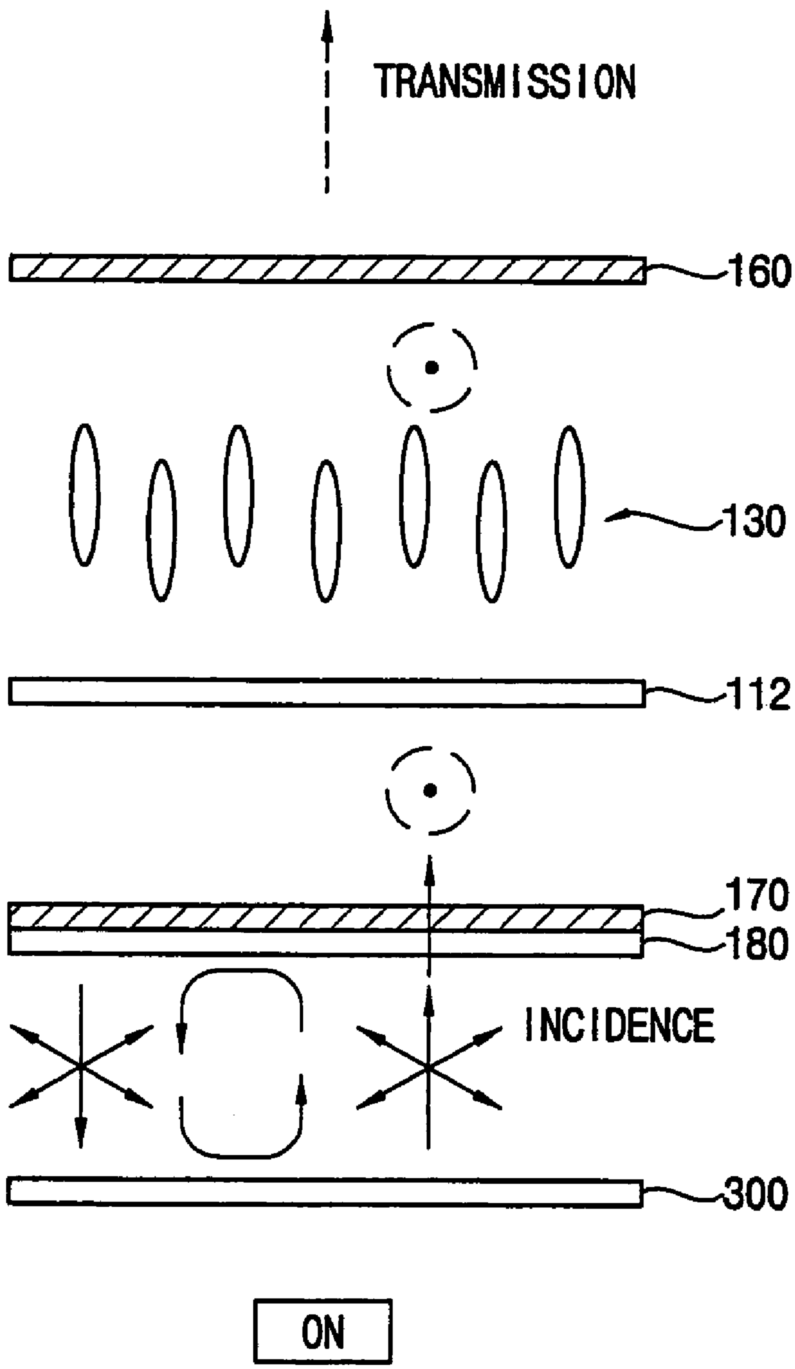

FIG.7A

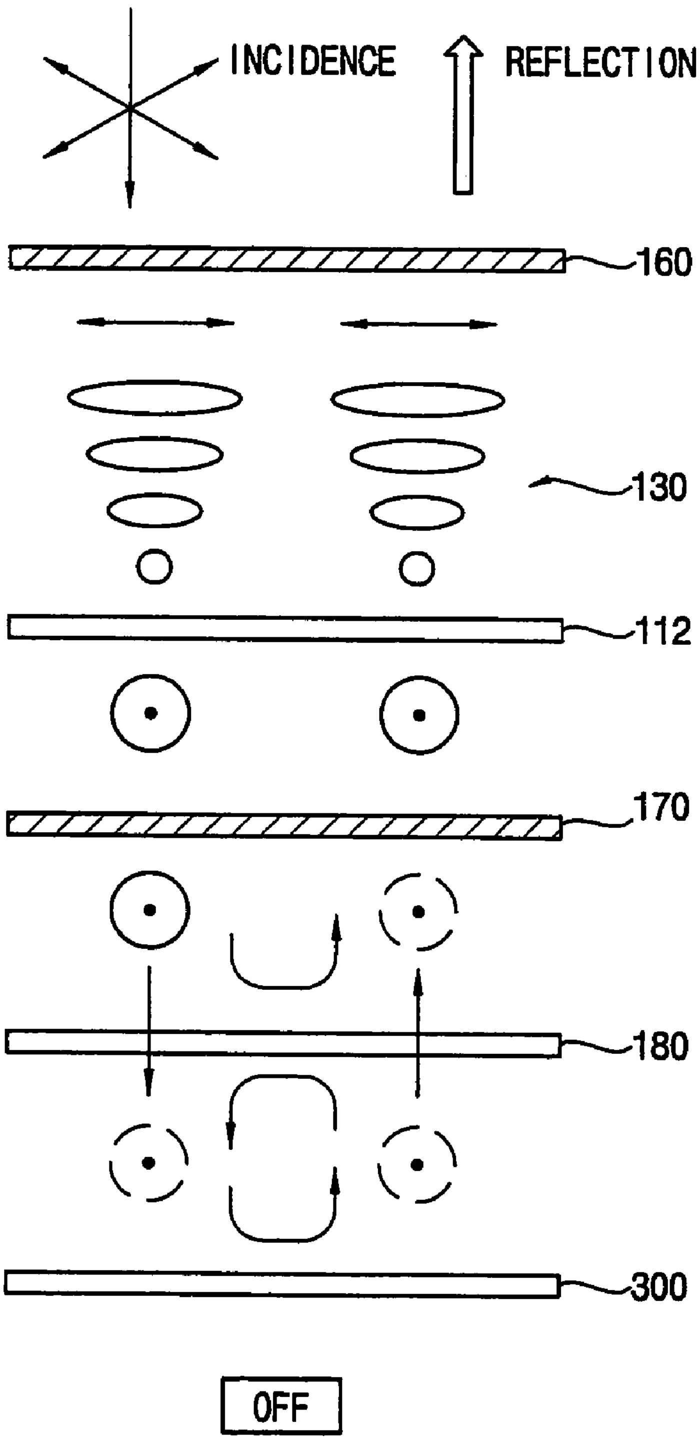

FIG.7B

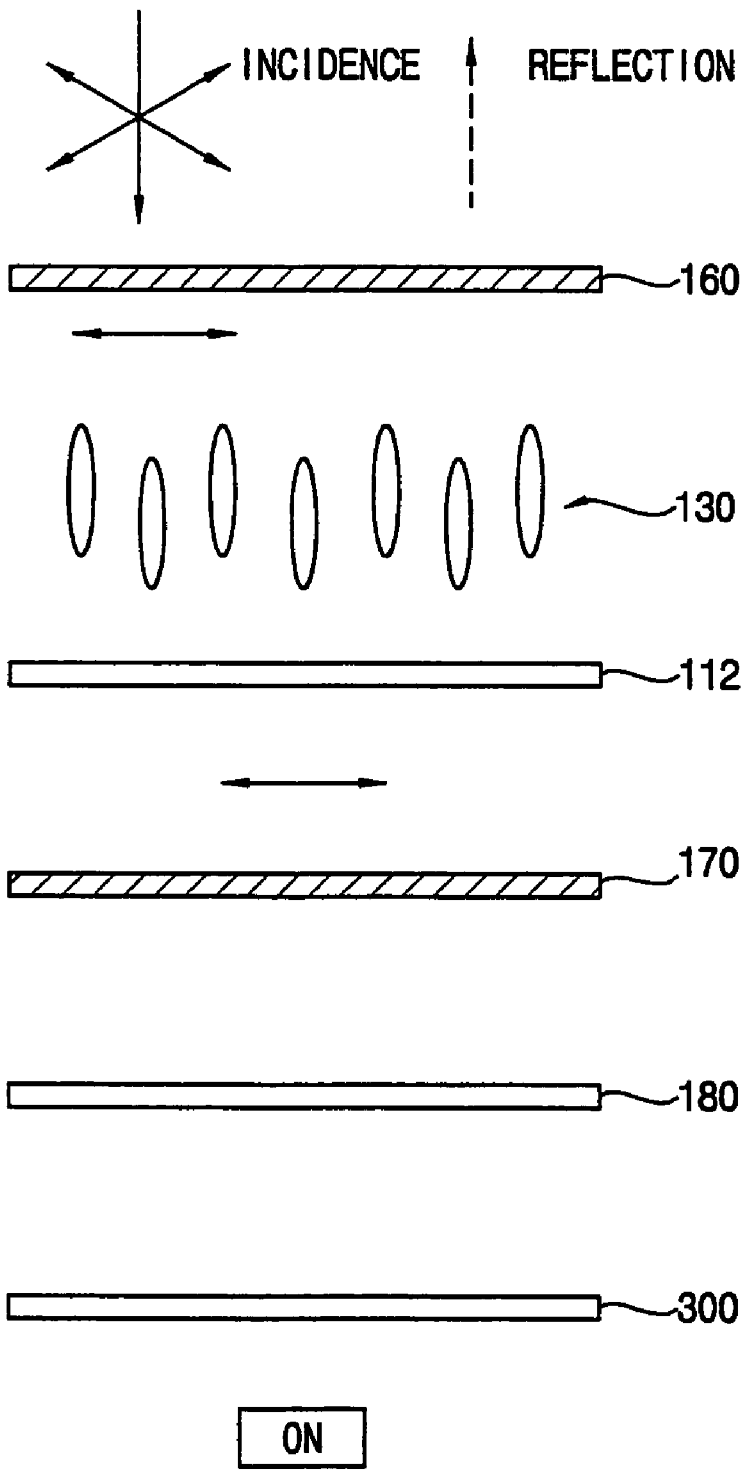

FIG.8A

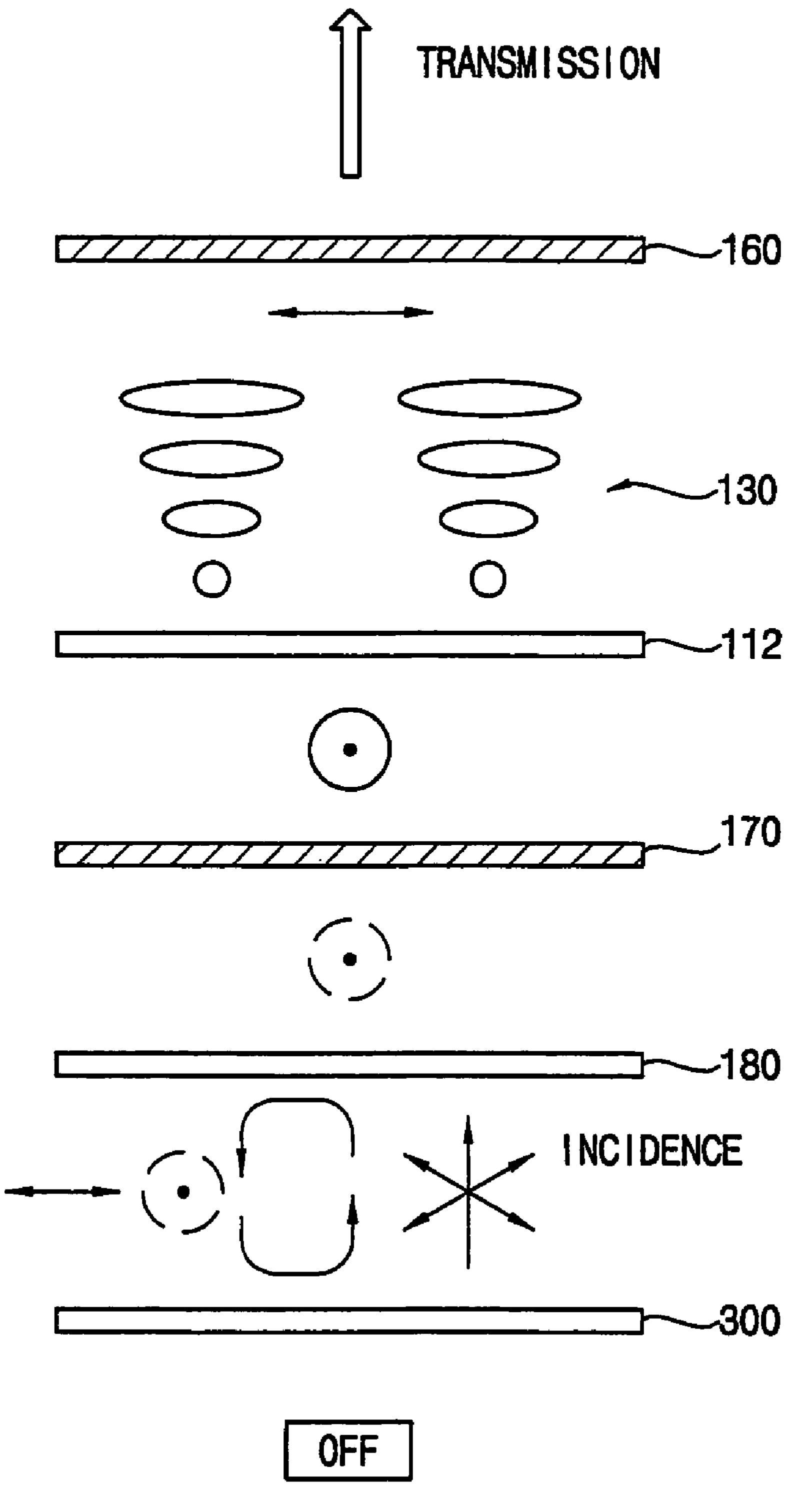

FIG.8B

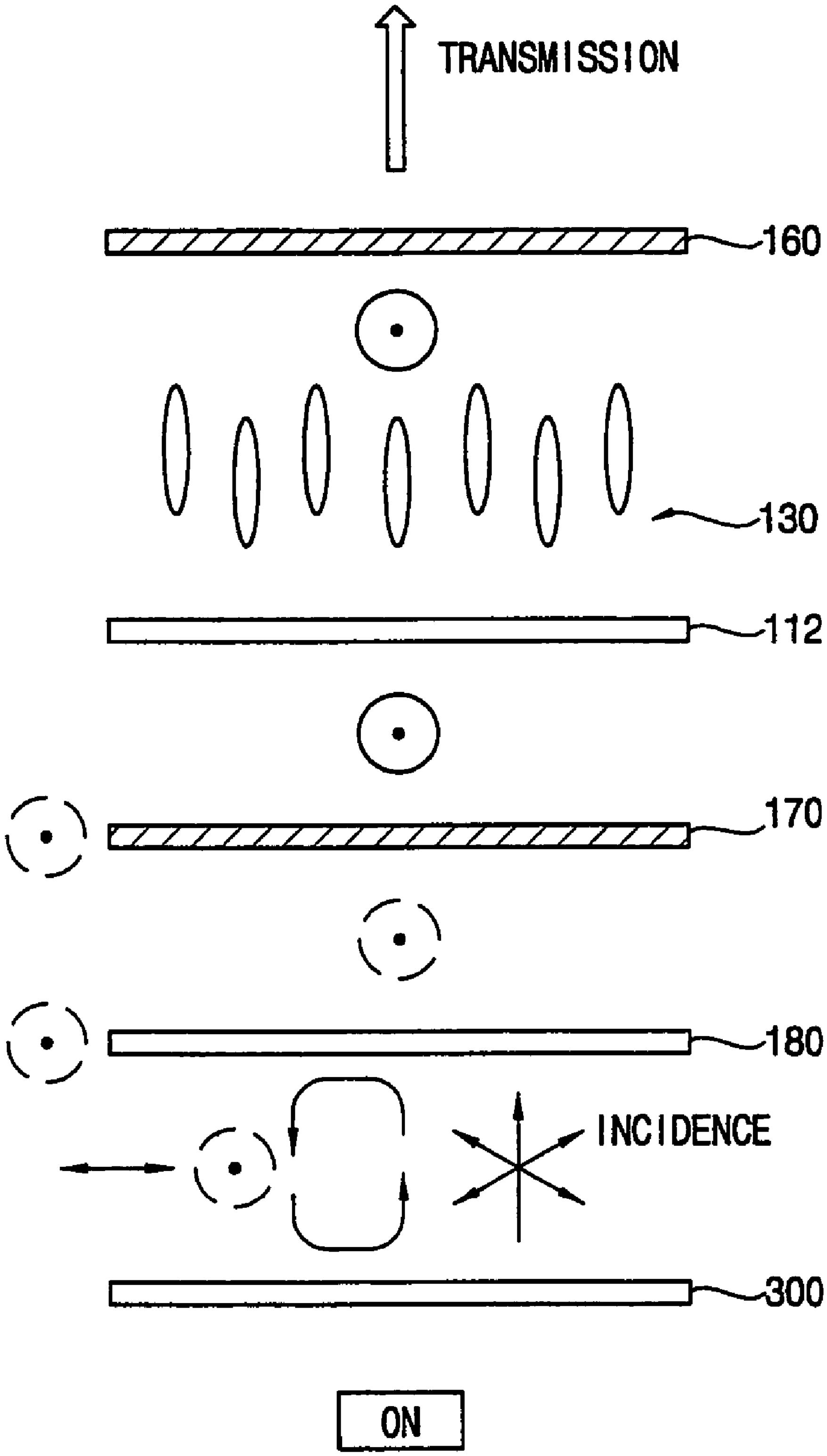

FIG.9

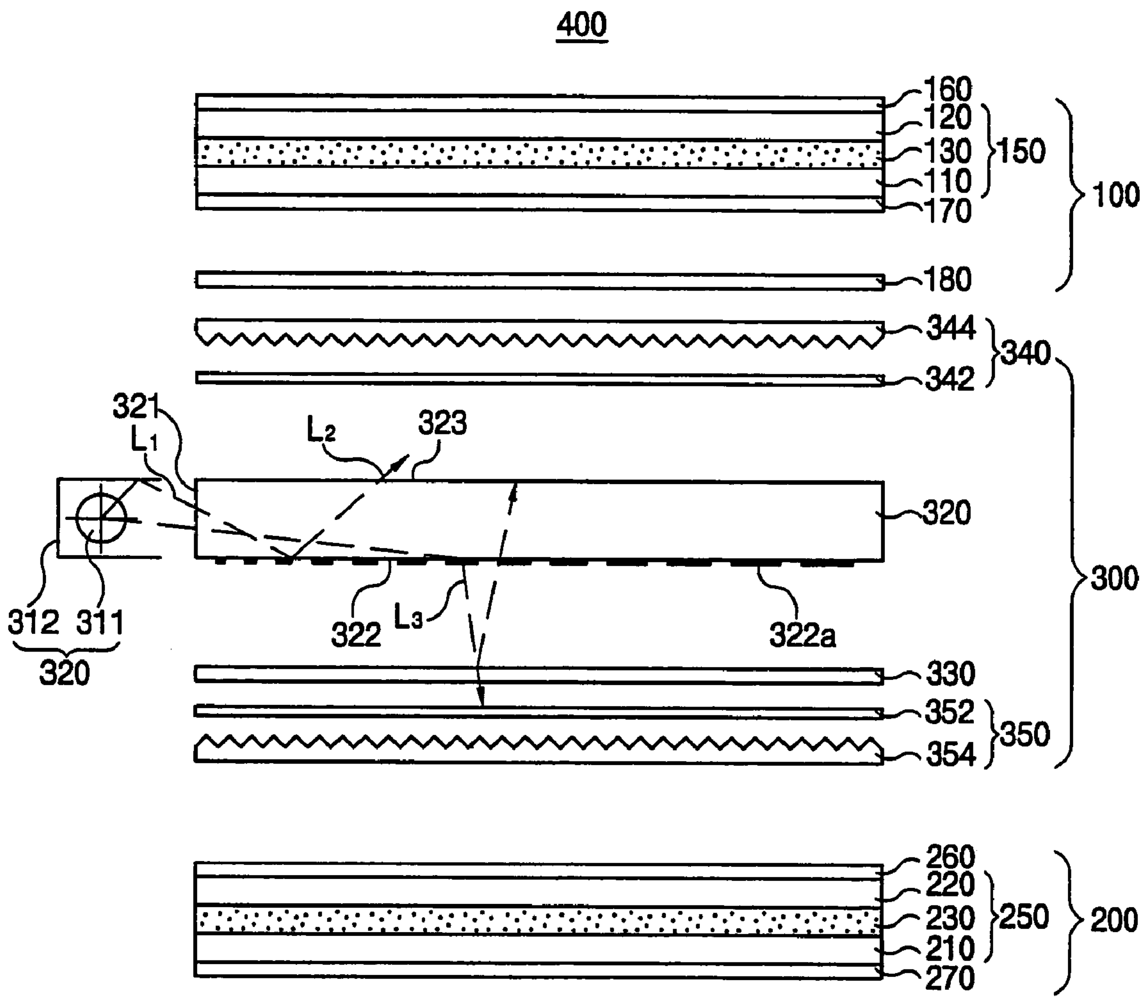
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FIG.10

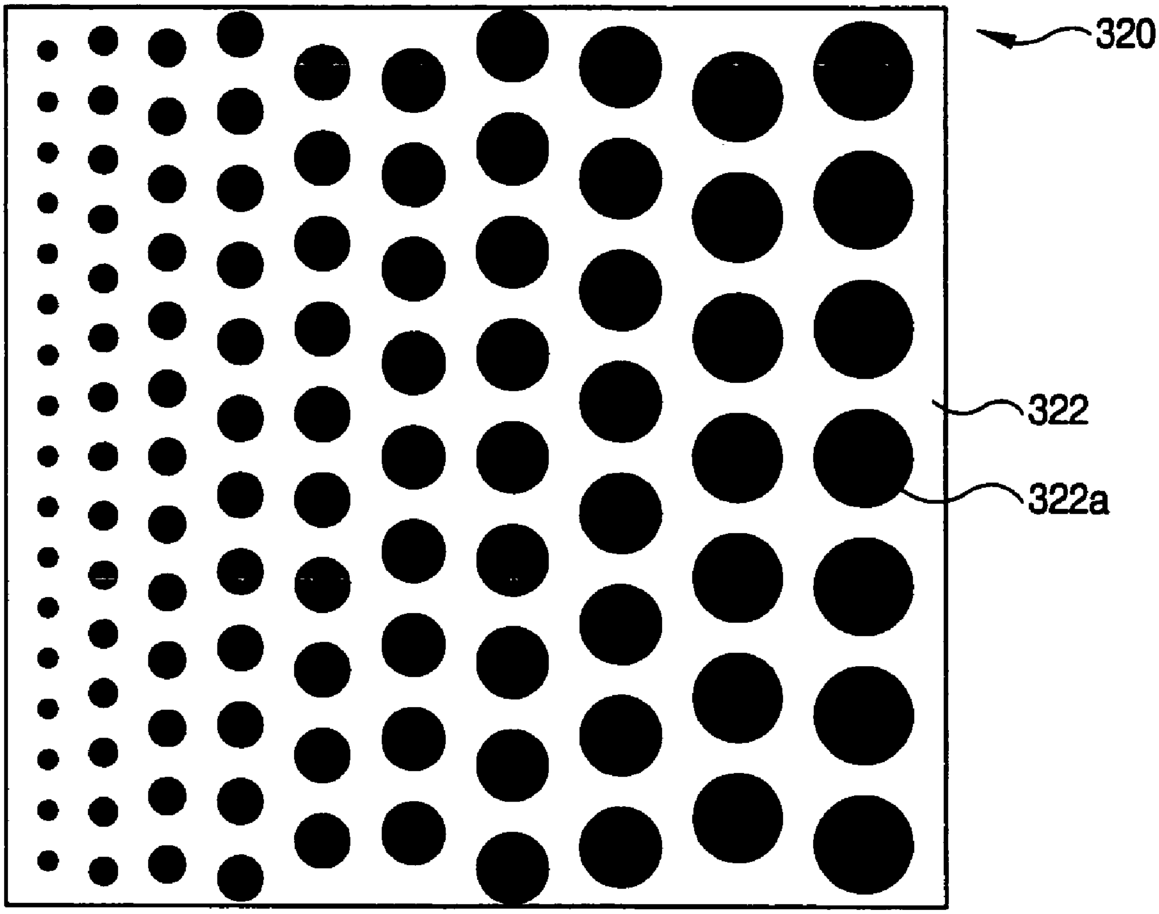

FIG.11

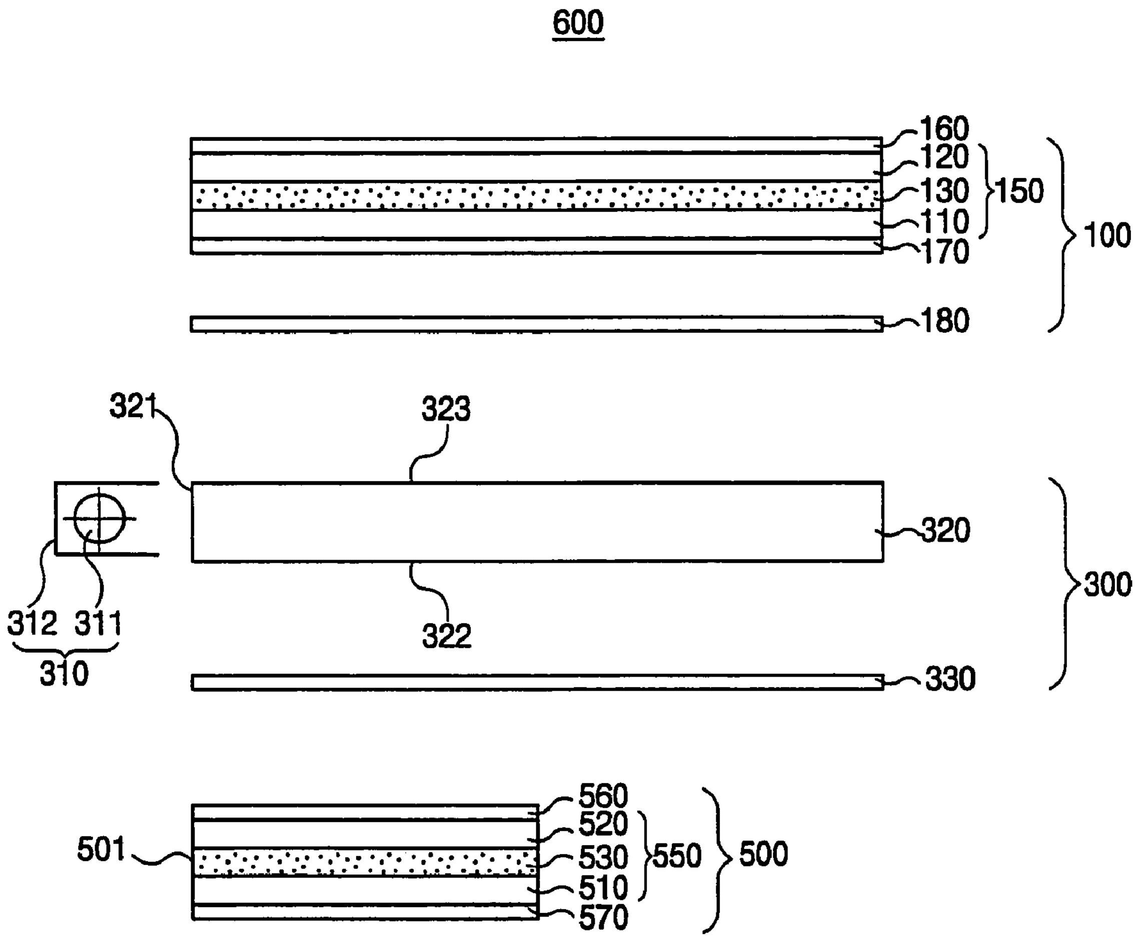
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FIG.12

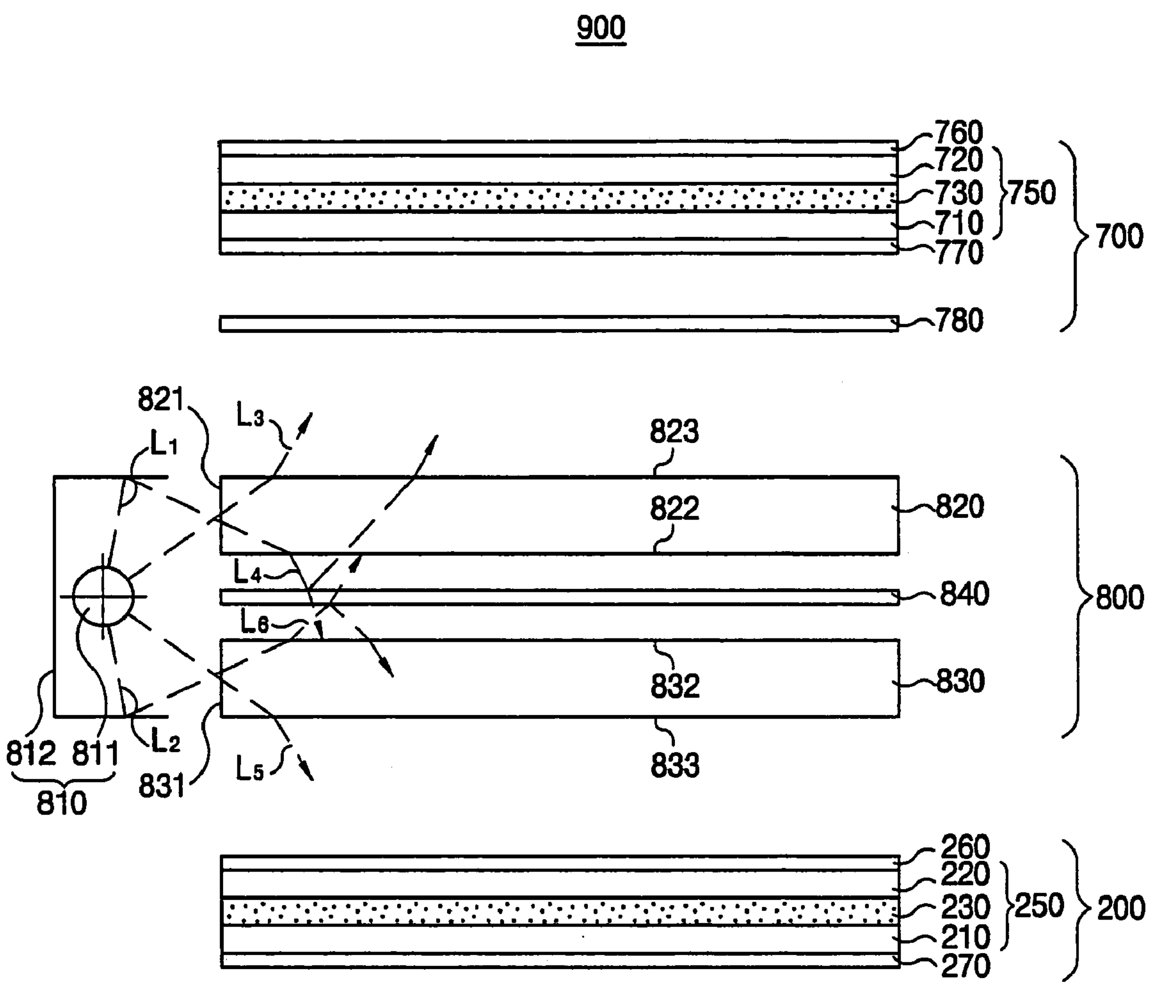
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FIG.13

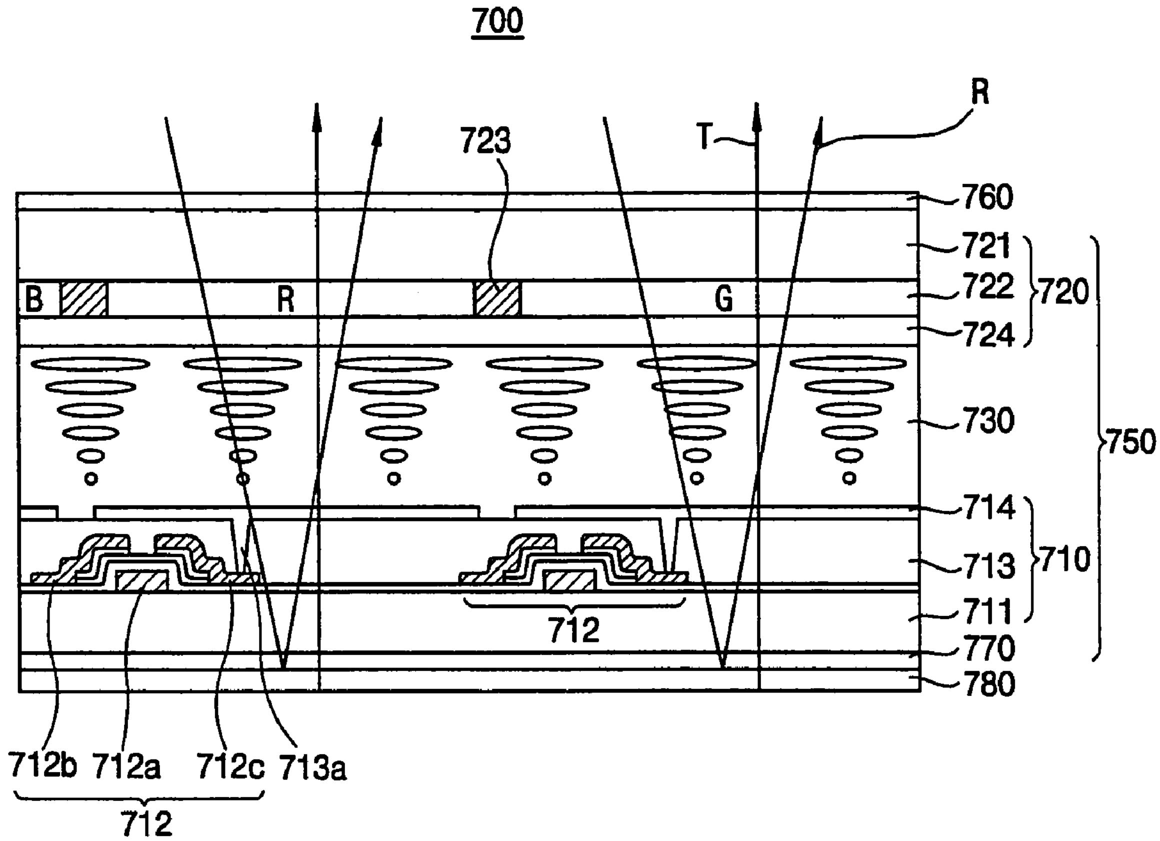
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FIG.14

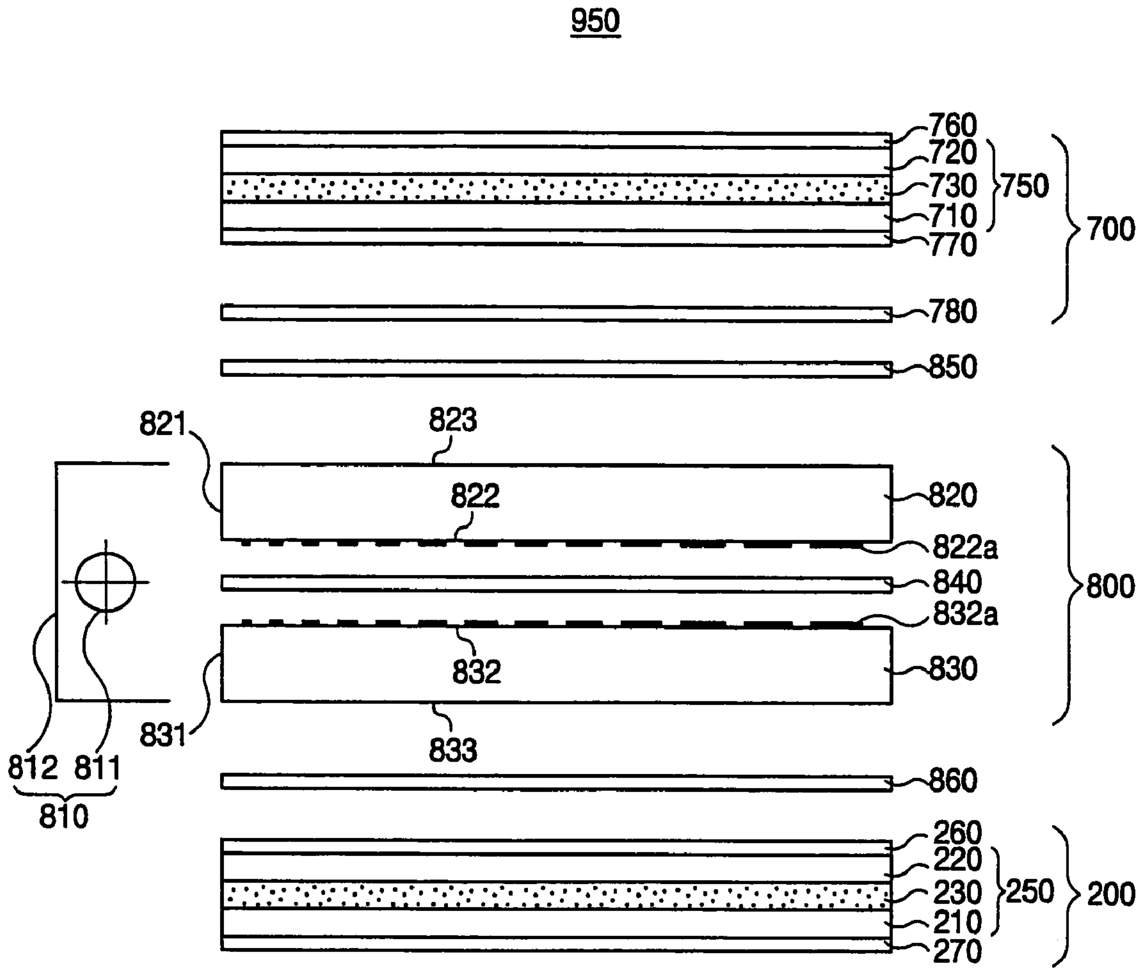
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FIG.15

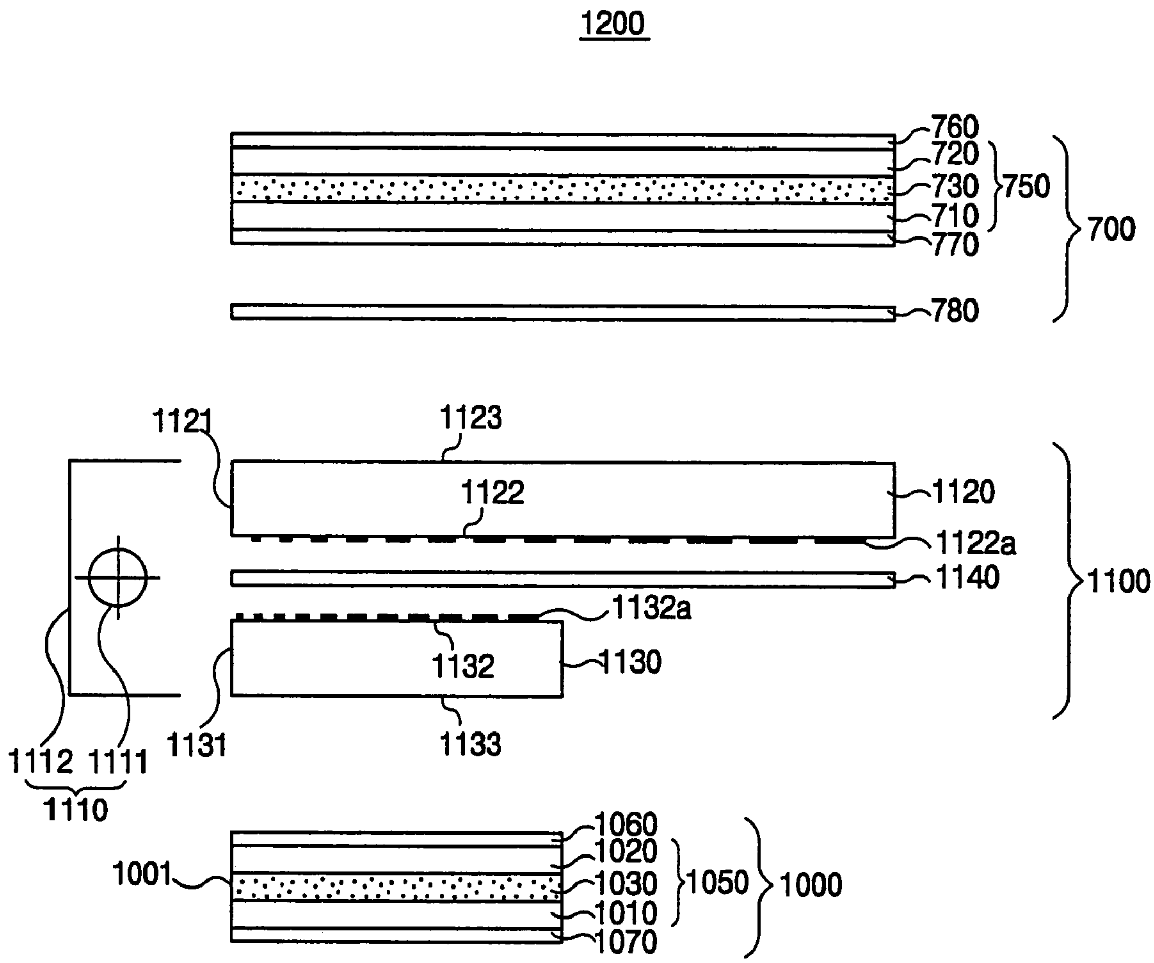
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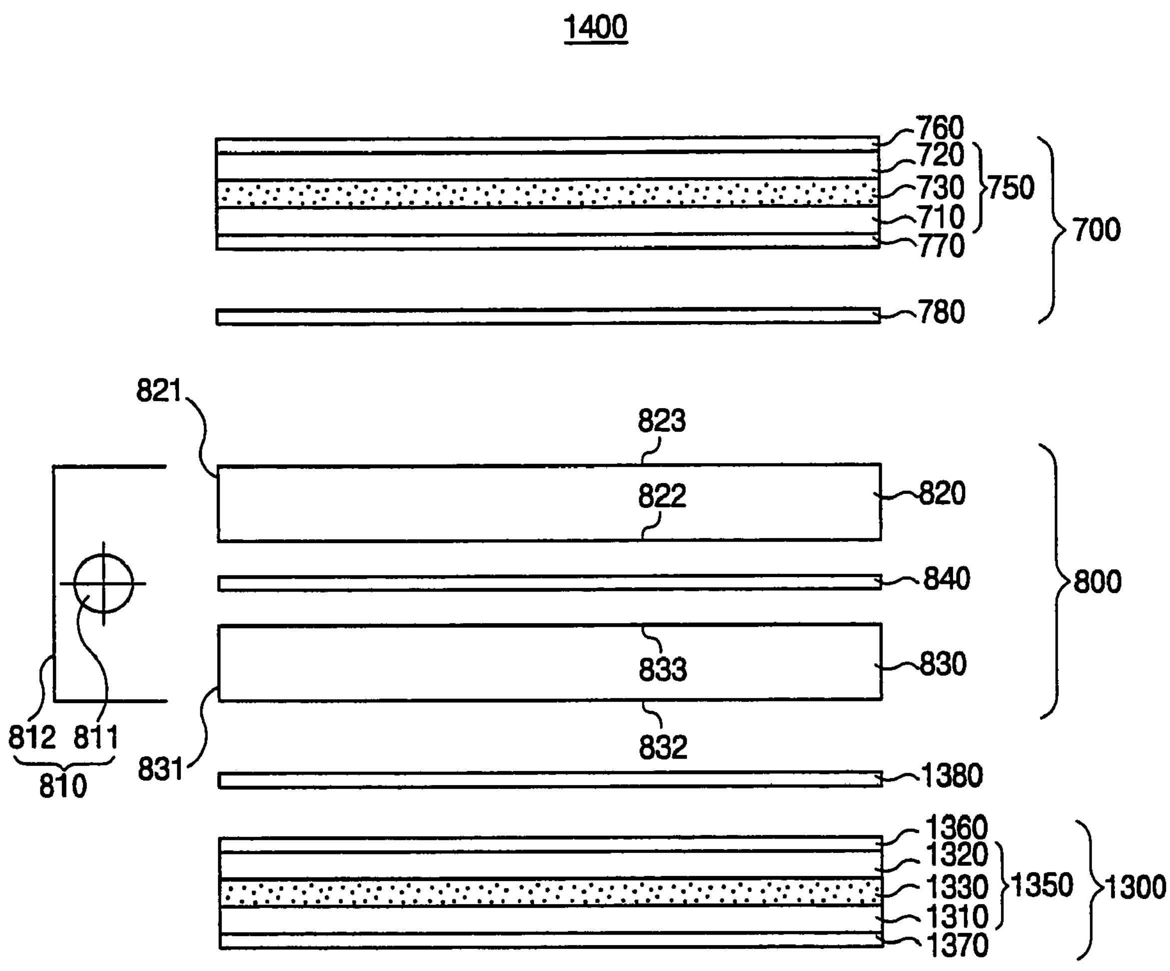
FIG.16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DUAL LIQUID CRYSTAL DISPLAY DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of the earlier filed non-provisional application, having U.S. application Ser. No. 10/454,700, filed on Jun. 3, 2003 now U.S. Pat. No. 6,831,711, which is incorporated herein in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a liquid crystal display (LCD) device, and more particularly to a liquid crystal display device in which a light loss of the liquid crystal display device is reduced in a transmission mode and a bi-directional display is provided.

2. Description of the Related Art

In these days, electronic display devices become more important for communicating and processing various information. Also, various types of electronic display devices are widely used in different industrial fields.

Generally, an electronic display device visually provides a variety of information to a user. In other words, an electrical information signal output from electronic devices is converted into a visible optical information signal in an electronic display device. Such an electronic display device serves as an interfacing means between a user and the electronic devices.

Meanwhile, owing to developments in the semiconductor technology, recent electronic devices are generally driven by lower voltage and lower power, and have a slimmer size and a lighter weight. With such a trend, a flat panel type display device which is slimmer and lighter and requires lower driving voltage and power becomes in more demand and desirable.

An LCD device among the various types of flat panel display devices is much slimmer and lighter than any other display devices, and has a lower driving voltage and lower power consumption, and also has the displaying quality similar to that of CRT-type display devices. Therefore, LCD devices are widely used in various electronic equipments.

Recently, an LCD device for performing a bi-directional image display has been developed.

Specifically, a conventional LCD device for performing the bi-directional image display includes a backlight, a first LCD panel and a second LCD panel. The first LCD panel is disposed above (or below) the backlight, and the second LCD panel is disposed below (or above) the backlight.

In the conventional LCD device for performing the bi-directional image display, light radiated from a lamp(s) is divided into two groups of light. A first group of light is provided to the first LCD panel, and a second group of light is provided to the second LCD panel. The conventional LCD device only has the function of dividing the light radiated from the lamp(s), but does not have the function of regulating an amount of each of the two groups. It is thus desired that an LCD device can divide the light radiated from the lamp(s) into two groups and also can regulate the amount of each of the two groups.

An LCD panel, which is available for the LCD device capable of performing the bi-directional image display, may have a structure in which the LCD panel can display images in a transmission mode or a reflection mode according to an amount of external light. The LCD panel includes a first substrate, a second substrate, a liquid crystal layer interposed between the first and second substrates, and pixel electrodes. The pixel electrodes are formed on the first substrate, and each of the pixel electrodes has a transparent electrode region and a reflective electrode region. Light is transmitted through the transparent electrode region in the transmission mode, and is reflected by the reflective electrode region in the reflection mode. Accordingly, the LCD panel displays images by means of the transparent electrode region in the transmission mode, and displays images by means of the reflective electrode region in the reflection mode.

The conventional LCD device having the above structure has at least the following problems.

First, since a display area of the LCD device is divided into a transmission area used in the transmission mode and a reflection area used in the reflection mode, it is not effective in aspect of utilization of the display area.

Second, since the conventional LCD device has to employ the wide band ¼ wavelength phase difference plates covering an overall frequency band of the visible ray, as well as a first and a second polarizing plates attached on each of the first and second substrates, a manufacturing cost is elevated compared with a transmission type LCD device that displays images by means of a backlight disposed under the LCD panel.

Third, since the polarization characteristic in the transmission mode causes a light loss of 50%, there are drawbacks in that a light transmissivity decreases by 50% and a contrast ratio (C/R) is lowered.

Fourth, since Δnd (Δn: a value for representing optical anisotropy or refractive anisotropy; d: cell gap) of a liquid crystal layer is only 0.24 μm which is a half of Δnd (0.48 μm) of the conventional transmission type LCD device, the cell gap of the liquid crystal cell should be decreased to a level of 3 μm, and the Δn of the liquid crystal also should be decreased. Accordingly, there are problems in that the manufacturing process becomes difficult and degeneration in the reliability of the liquid crystal is caused.

SUMMARY OF THE INVENTION

Accordingly, the present invention is to solve the aforementioned and other problems of the conventional art, and it is an object of the present invention to provide an LCD device capable of simplifying a structure of an LCD panel, decreasing light loss in the transmission mode and performing a bi-directional image display.

In one aspect, there is provided a liquid crystal display device comprising: a first display unit including a first liquid crystal display panel having a first substrate, a second substrate and a first liquid crystal layer between the first and second substrates, and a transflective film disposed under the first liquid crystal display panel, the transflective film having a plurality of layers in which a first layer and a second layer having different refractivity indexes from each other are alternately stacked, so that the transflective film partially reflects and partially transmits incident light incident onto the transflective film; a second display unit including a second liquid crystal display panel having a third substrate, a fourth substrate and a second liquid crystal layer between the third and fourth substrates; and a light supplying unit disposed between the first and second display units, the light supplying unit generating a first light to provide the first display unit with a first part of the first light and the second display unit with a second part of the first light, and the light supplying unit controlling an amount of the first and second

parts of the first light to regulate a contrast ratio of a luminance between the first and second display units.

According to another aspect of the invention, there is provided a liquid crystal display device comprising: a first display unit including a first liquid crystal display panel having a first substrate, a second substrate and a first liquid crystal layer disposed between the first and second substrates, and a first transflective film disposed under the first liquid crystal display panel, the first transflective film having a plurality of layers in which a first layer and a second layer having different refractivity indexes from each other are alternately stacked, so that the first transflective film partially reflects and partially transmits a first incident light incident onto the first transflective film; a second display unit including a second liquid crystal display panel having a third substrate, a fourth substrate and a second liquid crystal layer disposed between the third and fourth substrates; and a light supplying unit disposed between the first and second display units, the light supplying unit dividing a first light, which is a first part of a light generated from an light source, into a third light and a fourth light to provide the first and second display units with the third and fourth light, respectively, and dividing a second light, which is a second part of the light generated from the light source, into a fifth light and a sixth light to provide the first and second display units with the fifth and sixth light, respectively, the light supplying unit controlling an amount of the third, fourth, fifth and sixth light to regulate a contrast ratio of a luminance between the first and second display units.

In an exemplary embodiment, the LCD device includes a first transflective film disposed at one of the first and second display units. The first transflective film has a plurality of layers in which a first layer and a second layer having different refractivity indexes from each other are alternately stacked, so that the first transflective film partially reflects and partially transmits a first incident light incident on the first transflective film. The LCD device includes a light supplying unit disposed between the first and second display units. The light supplying unit controls an amount of the light that is provided to the first and second display units, to thereby regulate a contrast ratio of a luminance between the first and second display units. Therefore, the structure of an LCD panel for performing a bi-directional image display can be simplified, and the light loss in the transmission mode can be reduced.

In another exemplary embodiment, the LCD device includes an anisotropy transflective film or an isotropy transflective film disposed at one of the first and second display units. The anisotropy transflective film has an optical characteristic in which light components in a specific direction are strongly reflected and polarization components in a direction perpendicular to the specific direction are partially transmitted and reflected depending on polarized state and direction of the incident light incident thereto. The isotropy transflective film has an optical characteristic in which light components are partially transmitted and reflected independent of polarized state and direction of the incident light. As a result, by a light restoring process occurring between the transflective film and the backlight, the restored light is transmitted through the transflective film repeatedly, so that transmissivity and light efficiency can be enhanced.

Further, the LCD device has no reflection electrode within liquid crystal (LC) cell and has no ¼-wavelength phase difference plate on each of the first substrate and the second substrate. Accordingly, compared with a conventional LCD device, the LCD device of the present invention can be made in more simple structure, and degeneration in the reliability of the liquid crystal can be prevented.

Furthermore, since the light supplying unit disposed between the first and second display units regulates the luminance of the light generated from the lamp to provide the first and second display units with the light of which luminance is regulated, the LCD device of the present invention satisfies the demand from users.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and advantages of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

FIG. **1** is a sectional view showing a liquid crystal display device according to an exemplary embodiment of the present invention;

FIG. **2** is a sectional view showing a first display unit of FIG. **1**;

FIG. **3** is a schematic view showing a structure of a transflective film of FIG. **1**;

FIGS. **4**A and **4**C are sectional views for illustrating a position of a light scattering layer that is available for the liquid crystal display device of FIG. **1**;

FIGS. **5**A and **5**B are schematic views for illustrating an operation mechanism of the liquid crystal display device of FIG. **1** for which an integrally formed transflective film is available in the reflection mode;

FIGS. **6**A and **6**B are schematic views for illustrating an operation mechanism of the liquid crystal display device of FIG. **1** for which an integrally formed transflective film is available in the transmission mode;

FIGS. **7**A and **7**B are schematic views for illustrating an operation mechanism of the liquid crystal display device of FIG. **1** for which a separation type transflective film is available in the reflection mode;

FIGS. **8**A and **8**B are schematic views for illustrating an operation mechanism of the liquid crystal display device of FIG. **1** for which a separation type transflective film is available in the transmission mode;

FIG. **9** is a schematic view showing a structure of a liquid crystal display device of FIG. **1** further including a light reflection pattern and optical sheets;

FIG. **10** is a plane view showing the light reflection pattern formed on a light guiding member of FIG. **9**;

FIG. **11** is a sectional view showing a liquid crystal display device according to another exemplary embodiment of the present invention;

FIG. **12** is a sectional view showing a liquid crystal display device according to another exemplary embodiment of the present invention;

FIG. **13** is a view showing a first display unit of FIG. **12**;

FIG. **14** is a schematic view showing a structure of the liquid crystal display device of FIG. **12** further including light reflection patterns and optical sheets;

FIG. **15** is a sectional view showing a liquid crystal display device according to another exemplary embodiment of the present invention; and

FIG. **16** is a sectional view showing a liquid crystal display device according to another exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Now, exemplary embodiments of the present invention will be described in detail with reference to the annexed drawings.

FIG. **1** is a sectional view showing a liquid crystal display device according to an exemplary embodiment of the present invention, and FIG. **2** is a sectional view showing a first display unit of FIG. **1**.

Referring to FIG. **1**, an LCD device includes a first display unit **100** for displaying first images, a second display unit **200** for displaying second images, and a light supplying unit (Hereinafter, refer to a backlight) **300** disposed between the first and the second display units **100**, **200**.

The first display unit **100** includes a first LCD panel **150**, a first polarizing plate **160**, a second polarizing plate **170** and a transflective film **180**. The first LCD panel **150** includes a first substrate **110**, a second substrate **120** of which an lower surface is arranged facing the first substrate **110**, and a first liquid crystal layer **130** disposed between the first substrate **110** and the second substrate **120**.

As shown in FIG. **2**, on a first insulating substrate **111** is formed a first transparent electrode **112** made of, for example, conductive oxide film such as indium tin oxide (ITO), to thereby constitute the first substrate **110**. On a second insulating substrate **121** is formed a second transparent electrode **122** made of, for example, conductive oxide film such as ITO, to thereby constitute the second substrate **120**. The first transparent electrode **112** of the first substrate **110** is arranged facing the second transparent electrode **122** of the second substrate **120**.

The first liquid crystal layer **130** is made of, for example, 90° twisted TN (Twisted Nematic) liquid crystal composition. According to the present embodiment, the first liquid crystal layer **130** has "Δnd" of about 0.2–0.6 μm, that is a product of a refractive anisotropy (Δn) and a thickness (d) of the first liquid crystal layer **130**, preferably about 0.48 μm. In the LCD device of the present embodiment, the liquid crystal optical conditions of a conventional transmission-type LCD device may be adopted without a variation, thereby preventing the reliability of the liquid crystal from being affected.

On an upper surface of the first LCD panel **150** is disposed a first polarizing plate **160**, and a second polarizing plate **170** is formed on a lower surface of the first LCD panel **150**. The first and second polarizing plates **160** and **170** absorb a predetermined polarization component and transmit other polarization components, thereby allowing incident light to be transmitted in a specific direction. The first and second polarizing plates **160** and **170** are linear polarizers of which polarizing axes are arranged to be perpendicular to each other.

Under the second polarizing plate **170** is disposed a transflective film **180** including at least two transparent layers having different refractivity index values from each other, i.e., a first layer **181** and a second layer **182** alternately stacked as shown in FIG. **3**. The transflective film **180** partially reflects and partially transmits the incident light incident thereto. Accordingly, the LCD device in accordance with the present embodiment has a reflection light path (R) and a transmission light path (T). In the reflection light path (R), the incident light is incident toward the second substrate **120**, transmits through the first substrate **110**, is reflected by the transflective film **180**, and exits through the second substrate **120**. In the transmission light path (T), the incident light is incident from the backlight **300** onto the first substrate **110**, is transmitted through the transflective film **180**, and exits through the second substrate **120**.

Referring again to FIG. **1**, the second display unit **200** includes a second LCD panel **250**, a third polarizing plate **260**, a fourth polarizing plate **270**. The second LCD panel **250** includes a third substrate **210**, a fourth substrate **220** of which an lower surface is arranged facing the third substrate **210**, and a second liquid crystal layer **230** disposed between the third substrate **210** and the fourth substrate **220**.

On an upper surface of the second LCD panel **250** is disposed a third polarizing plate **260**, and a fourth polarizing plate **270** is formed on a lower surface of the second LCD panel **250**. The third and fourth polarizing plates **260** and **270** absorb a predetermined polarization component and transmit other polarization components, thereby allowing incident light to be transmitted in a specific direction. The third and fourth polarizing plates **260** and **270** are linear polarizers of which polarizing axes are arranged to be perpendicular to each other.

The backlight **300** is installed between the first and the second display units **100**, **200**. The backlight **300** generates light and provides the first and second display units **100**, **200** with a part of the generated light.

As shown in FIG. **1**, the backlight **300** includes a light guiding member **320** and a luminance controlling member **330**. The light guiding member **320** guides the light generated form a lump unit **310**, and the luminance controlling member **330** controls the luminance of the light that is supplied to the first and second display units **100**, **200**.

The light guiding member **320** has a shape of a rectangular parallelepiped plate, and includes four side faces including an incident face **321**, a light reflective-transmissive face **322** and a light exiting face **323**. The light exiting face **323** faces the light reflective-transmissive face **322**.

The light incident face **321** receives first light L**1** generated from the lamp unit **310**. The lamp unit **310** includes a lamp **311**, a lamp reflector **312** covering the lamp **311** to reflect the first light L**1**. The lamp **311**, preferably, employs a linear light source such as a cold cathode fluorescent lamp (CCFL), but is not limited to the linear light source. The lamp **311** may be a point light source such as a light emitting diode (LED).

The first light L**1** generated from the lamp **311** is incident into the light guiding member **320** through the light incident face **321**. The light guiding member **320** divides the first light L**1** to exit second and third lights L**2**, L**3**. The light guiding member **320** exits the second light L**2** or a part of the first light L**1** toward the first display unit **100**, and exits the third light L**3** or the other part of the first light L**1** toward the second display unit **200**. Specifically, the second light L**2** includes the light exiting directly from the light exiting face **323** and the light being reflected by the light reflective-transmissive face **322**. The third light L**3** is the light that passes through the light reflective-transmissive face **322** to proceed toward the second display unit **200**.

The light guiding member **320** is able to provide both the first and second display units **100**, **200** with light. However, it is difficult for the light guiding member **320** to control the luminance of the light supplied to the first and second display units **100**, **200**. Accordingly, the backlight **300** further includes a luminance controlling member **330** to as to regulate the luminance between the first display unit **100** and the second display unit **200**.

The luminance controlling member **330** reflects a part of the third light L**3** to provide the first display unit **100** with the reflected part of the third light L**3** through the light

guiding member **320**, and transmits the other part of the third light L**3** to provide the second display unit **200** with the other part of the third light L**3**.

The luminance controlling member **330** may have a sheet shape or a plate shape thicker than the sheet shape, and is made of, for example, polyethylene terephthalate (PET) treated by foaming agent. The luminance controlling member **330** reflects about 80% of the third light L**3** and transmits about 20% of the third light L**3** according to one embodiment of the present invention. In addition, the luminance controlling member **330** reflects about 20% of the third light L**3** and transmits about 80% of the third light L**3** according to another embodiment of the present invention.

The material of the luminance controlling member **330** is not limited to polyethylene terephthalate (PET) treated by foaming agent. The luminance controlling member **330** may be made of any material that can partially reflect and partially transmit light.

FIG. **3** is a schematic view showing a structure of the transflective film of FIG. **1**.

Referring to FIG. **3**, when it is assumed that the transflective film **180** has a film thickness in direction z and a film plane in x-y plane, the transflective film **180** according to one aspect of the invention is characterized such that the first layer **181** thereof has a refractive anisotropy in its film plane, i.e., x-y plane, and the second layer **182** does not have a refractive anisotropy in its film plane. The film plane is parallel to a surface of the transflective film.

The transflective film **180** has various transmissivity and reflectivity characteristics depending on a polarized state and a direction of the incident light. For instance, when it is assumed that a direction parallel to an elongated direction of the transflective film **180** is x-direction and a direction perpendicular to the elongated direction is y-direction, the first layer **181** having a high refractivity and refractive anisotropy within the film plane and the second layer **182** not having refractive anisotropy each have three main refractive indexes, n_x, n_y, and n_z, that satisfy the following relationships (1):

$$n1_x = n1_z \neq n1_y;$$

$$n2_x = n2_y = n2_z;$$

$$n1_x \neq n2_x;$$

$$n1_y \neq n2_y; \text{ and}$$

$$|n1_x - n2_x| < |n1_y - n2_y| \quad (1).$$

(n**1**x, n**1**y, n**1**z denote main refractive indexes of the first layer in the x-axis, y-axis, z-axis, respectively, and n**2**x, n**2**y, n**2**z denote main refractive indexes of the second layer in an x-axis, y-axis, z-axis, respectively)

Thus, if a refractivity difference in the x-direction between the first layer **181** and the second layer **182** is less than a refractivity difference in the y-direction between the first layer **181** and the second layer **182**, when a non-polarized light is incident in the direction perpendicular to the film plane, i.e., z-direction, a polarization component polarized parallel to the y-direction is mostly reflected due to a high difference in the refractivity based on Fresnel's equation, but a polarization component polarized parallel to the x-direction partially is transmitted and reflected due to a low difference in the refractivity.

There are disclosed methods for enhancing the display brightness by using a reflection type polarizing plate made of dielectric multilayered film having birefringence in Japanese Patent Laid Open Publication No. 9-506985 and International Patent Publication No. WO 97/01788. The dielectric multilayered film having birefringence has a structure in which two kinds of polymer layers are alternately stacked. One of the two kinds of polymer layers is selected from a polymer group having a high refractivity and the other is selected from a polymer group having a low refractivity.

Hereinafter, the structure of the dielectric multilayered film is reviewed in an aspect of optical property.

For instance, when it is assumed that there is the following relationship between a first layer in which a material having a high refractivity is elongated, and a second layer in which a material having a low refractivity is elongated:

$$n1_x = n1_z = 1.57,\ n1_y = 1.86; \text{ and}$$

$$n2_x = n2_y = n2_z = 1.57.$$

Thus, in case that refractivity values of the first and second layers in the x-direction and the z-direction are identical to each other and refractivity values of the first and second layers in the y-direction are different from each other, when a non-polarized light is incident in the direction perpendicular to the film plane, i.e., z-direction, polarization components in the x-direction are all transmitted, polarization components in the y-direction are all reflected based on Fresnel's equation. A representative example of birefringence dielectric multilayered films having the above characteristics is DBEF (Dual brightness enhancement film) made by 3M company. The DBEF has a multilayered structure in which two kinds of films made of different material are alternately stacked to form a few hundred layers. In other words, polyethylene naphtalate layer having a high birefringence and polymethyl methacrylate (PMMA) layer are alternately stacked to form the DBEF layer. Since naphthalene radical has a flat plane structure, when these radicals are adjacently placed to each other, it is easy to stack the polyethylene naphtalate layer and the DBEF layer, so that the refractivity in the stacking direction becomes considerably different from those in other directions. On the contrary, since the PMMA is an amorphous polymer and is isotropically aligned, the PMMA has an identical refractivity in all directions.

The DBEF made by 3M company transmits all x-directional polarization components and reflects all y-directional polarization components, while the transflective film **180** according to one aspect of the invention mostly reflects a specific-directional (for instance, y-directional) polarization component, but partially reflects and transmits polarization component, which is polarized in a direction (for instance, x-direction) perpendicular to the specific direction. The transflective film **180** may be made by vertically attaching two anisotropic transflective films each having transmissivity and reflectivity varying depending on polarized state and direction of light incident on the transflective film **180**. Also, the transflective film **180** may be made by attaching an anisotropic transflective film having various transmissivity and reflectivity depending on polarized state and direction of the incident light and a transflective film having isotropic reflection and transmission characteristics independent of polarized state and direction of incident light. The two transflective films can be made in an integrally formed structure, or made in a separately formed film structure.

Also, according to another aspect of the invention, the transflective film **180** has isotropic reflection and transmission characteristics independent of a polarized state and a direction of the incident light. For instance, if it is assumed that a direction parallel to an elongated direction of the film is x-direction and a direction perpendicular to the elongated

direction of the film is y-direction, the first layer **181** having a high refractivity and the second layer **182** having a low refractivity both have a refractive isotropy in x-y plane of the film, and the first and second layers **181** and **182** each have three main refractive indexes, n_x, n_y, and n_z, that satisfy the following relationships:

$$n1_x = n1_y = n1_z; \text{ and}$$

$$n2_x = n2_y = n2_z \neq n1_z \quad (2).$$

Thus, in case that the first and second layers **181** and **182** have different refractivity index values in the z-direction, when non-polarized light is incident in the direction (i.e., z-direction) perpendicular to the film, polarization components in the x-direction are partially transmitted and reflected, and polarization components in the y-direction are partially transmitted and reflected according to Fresnels's equation. At this time, the reflectivity of the reflected light can be adjusted to match with characteristics of the LCD device by controlling the thickness or the refractivity of the first layer **181** or the second layer **182**. In other words, a reflection-characteristic-enhanced LCD device, enhances the reflectivity, whereas an LCD device, in which transmission characteristic is considered to be an important factor, lowers the reflectivity to thereby enhance the transmissvity.

As described above, the transflective film **180** of the invention can be formed to have an anisotropy characteristic in which transmissivity and reflectivity of the film **180** varies with a polarized state and a direction of the incident light, or can be formed to have an isotropy characteristic in which transmissivity and reflectivity of the film **180** do not depend on a polarized state and a direction of the incident light. In any case, it is desirable that the transflective film **180** has a reflectivity of more than or equal to about 4% with respect to polarization component in all directions when light is incident in a direction perpendicular to the film plane.

The transflective film **180** of the invention can be made in an integrally formed structure together with the second polarizing plate **170**, or made in a separately formed sheet structure separated from the second polarizing plate **170**. In case that the transflective film **180** is made in an integrally formed structure together with the second polarizing plate **170**, it is possible to decrease the thickness of a liquid crystal (LC) cell, and the LCD device has an advantage in an aspect of manufacturing cost.

In the above, there is explained a method of forming the transflective film **180** by depositing or coating the polymer multilayered film on a surface of the second polarizing plate **170**, which may be contrasted with the anti-reflection treatment in a polarizing plate. In other words, in the anti-reflection treatment, two kinds of transparent films having different refractivity are repeatedly deposited or coated in a constant thickness such that destructive interference occurs by multi-reflection within the polymer multilayered film. However, in order to form a transflective film capable of partially transmitting and partially reflecting an incident light, the film thickness should be adjusted such that constructive interference occurs.

FIGS. **4**A and **4**B are sectional views for illustrating a position of a light scattering layer that is available for the liquid crystal display device of FIG. **1**.

As shown in FIGS. **4**A and **4**B, the LCD device in accordance with the current embodiment may further include a light scattering layer **175** formed on the first substrate **110** or the second substrate **120** in order to prevent specular reflection and to properly diffuse the reflected light in various angles.

For instance, as shown in FIGS. **4**A and **4**B, it is possible to form the light scattering layer **175** between the first substrate **110** and the second polarizing plate **170**, or between the second substrate **120** and the first polarizing plate **160**. It is also possible to form the light scattering layer **175** between the second polarizing plate **170** and the transflective film **180**. The light scattering layer **175** may be made in an integrally formed structure together with the second polarizing plate **170** or the first polarizing plate **160**, or made in a separate sheet structure separated from the polarizing plates **160**, **170**. Further, the light scattering layer **175** can be made in the form of a plastic film in which transparent beads are dispersed. Moreover, the light scattering layer **175** can be made in a state in which beads are added to adhesive, which makes it possible to directly attach the first substrate **110** to the second polarizing plate **170**.

Furthermore, in order to optimize light efficiency in the LCD device in accordance with the current embodiment of the invention, it is possible to form a phase difference plate (not shown) on the first substrate **110** or the second substrate **120**. For instance, the phase difference plate is formed in an integrally formed structure together with polarizing plates **160**, **170** or a separate film structure separated from the polarizing plates **160**, **170** between the first substrate **110** and the second polarizing plate **170**, or between the second substrate **120** and the first polarizing plate **160**.

Hereinafter, there is described in detail an operation mechanism of the LCD device having the above structure.

FIG. **5**A through FIG. **6**B are schematic views for illustrating operation mechanisms of reflection mode and transmission mode in the LCD device in which the transflective film **180** is made an integrally formed structure together with the second polarizing plate **170**. Here, polarization directions of the light are represented on the basis of a polarizing axis of the first polarizing plate **160**, and partially reflected light and partially transmitted light are represented by a dotted line.

First, when a pixel voltage is not applied (OFF) in the reflection mode, as shown in FIG. **5**A, light that is incident from an external source is transmitted through the first polarizing plate **160**, so that the light is linearly polarized in a direction parallel to the polarizing axis of the first polarizing plate **160**. The linearly polarized light is transmitted through the liquid crystal layer **130** and the first transparent electrode **112**, so that the linearly polarized light is linearly polarized in a direction perpendicular to the polarizing axis of the first polarizing plate **160** and is then incident into the transflective film **180** made in an integrally formed structure together with the second polarizing plate **170**. At this time, since the polarizing axis of the second polarizing plate **170** is perpendicular to that of the first polarizing plate **160**, the light that is incident into the second polarizing plate **170** comes to have the direction parallel to the polarizing axis of the second polarizing plate **170**. Accordingly, the light linearly polarized in the direction parallel to the polarizing axis of the second polarizing plate **170** is partially transmitted through the transflective film **180** and is partially reflected by the transflective film **180**. In other words, in case that the transflective film **180** has the refractivity characteristic of the relationship (1), a polarization component, which is polarized in the x-direction parallel to the elongated direction of the transflective film **180**, of the light incident into the transflective film **180** is partially transmitted and reflected, whereas a polarization component which is polarized in the direction perpendicular to the elongated direction is mostly reflected. Further, in case that the transflective film **180** has the refractive characteristic of the relationship (2),

of the light incident into the transflective film **180**, the polarization components which are polarized in the x- and y-directions are partially transmitted and partially reflected.

Thus, the linearly polarized light reflected by the transflective film **180** is transmitted through the first transparent electrode **112** and the liquid crystal layer **130**, so that it is linearly polarized in the direction parallel to the polarizing axis of the first polarizing plate **160**. Afterwards, the light is transmitted through the first polarizing plate **160**, so that a white image is displayed. Also, the light transmitted through the transflective film **180** is restored between the transflective film **180** and the backlight **300**, and the restored light is repeatedly subject to the procedure of partial reflection and partial transmission. As a consequence, light loss is eliminated and reflectivity and light efficiency are enhanced.

When a maximum pixel voltage is applied (ON) in the reflection mode, as shown in FIG. **5**B, light incident from an external source is transmitted through the first polarizing plate **160**, so that the light is linearly polarized in a direction parallel to the polarizing axis of the first polarizing plate **160**. Afterwards, the linearly polarized light is transmitted through the liquid crystal layer **130** without a variation in the polarized state, and is then incident into the transflective film **180** integrally formed with the second polarizing plate **170**. At this time, since the linearly polarized light is perpendicular to the polarizing axis of the second polarizing plate **170**, the light is all absorbed in the second polarizing plate **170**. Thus, the linearly polarized light is not reflected by the transflective film **180**, so that a black image is displayed.

When a pixel voltage is not applied (OFF) in the transmission mode, as shown in FIG. **6**A, light irradiated from the backlight **300** is incident into the transflective film **180** integrally formed with the second polarizing plate **170**. In case that the transflective film **180** has the refractive characteristic of the relationship (1), a polarization component, which is polarized parallel to the x-direction, of the light parallel to the polarizing axis of the second polarizing plate **170** is partially transmitted and reflected, whereas a polarization component which is polarized parallel to the y-direction is mostly reflected. Also, in case that the transflective film **180** has the refractive characteristic of the relationship (2), the light, which is parallel to the polarizing axis of the second polarizing plate **170**, is partially transmitted and partially reflected because all polarization components which are polarized in the x-direction and y-direction are partially transmitted and reflected.

Thus, the light that has been transmitted through the transflective film **180** and the second polarizing plate **170** becomes a linearly polarized light having a vibrating direction parallel to the polarizing axis of the second polarizing plate **170**. The linearly polarized light is transmitted through the first transparent electrode **112** and the liquid crystal **130**, so that it is linearly polarized in a direction parallel to the polarizing axis of the first polarizing plate **160**. Accordingly, the light linearly polarized in the direction parallel to the polarizing axis of the first polarizing plate **160** is transmitted through the first polarizing plate **160**, so that a white image is displayed. Also, light reflected by the transflective film **180** is restored between the backlight **300** and the transflective film **180**, and then is repeatedly subject to the above steps. Thus, polarization components parallel to the x-direction or polarization components parallel to the x- and y-directions are successively transmitted through the transflective film **180** to be used, so that light loss is reduced and transmissivity and light efficiency are enhanced.

When a maximum pixel voltage is applied (ON) in the transmission mode, as shown in FIG. **6**B, light irradiated from the backlight **300** is incident into the transflective film **180** integrally formed with the second polarizing plate **170**, so that the light parallel to the polarizing axis of the second polarizing plate **170** is partially transmitted and reflected. The light that has been transmitted through the transflective film **180** and the second polarizing plate **170** is converted into light lineally polarized in the direction parallel to the polarizing axis of the second polarizing plate **170**, i.e., in the direction perpendicular to the polarizing axis of the first polarizing plate **160**. The linearly polarized light is transmitted through the first transparent electrode **112** and the liquid crystal layer **130** without a variation in the polarized state. Accordingly, the light linearly polarized in the direction perpendicular to the polarizing axis of the first polarizing plate **160** is not transmitted through the first polarizing plate **160**, so that a black image is displayed.

FIG. **7**A through FIG. **8**B are schematic views for illustrating an operation mechanism in the transmission mode and the reflection mode of an LCD device in which the transflective film **180** is separated from the second polarizing plate **170** and is made in a sheet structure. Here, polarization directions of the light are represented on the basis of a polarizing axis of the first polarizing plate **160**, and partially reflected light and partially transmitted light by a dotted line.

First, when a pixel voltage is not applied (OFF) in the reflection mode, as shown in FIG. **7**A, light incident from an external source is transmitted through the first polarizing plate **160**, so that the light is linearly polarized in a direction parallel to the polarizing axis of the first polarizing plate **160**. The linearly polarized light is transmitted through the liquid crystal layer **130** and the first transparent electrode **112**, so that the linearly polarized light is linearly polarized in a direction perpendicular to the polarizing axis of the first polarizing plate **160** and is then incident into the second polarizing plate **170**. At this time, since the polarizing axis of the second polarizing plate **170** is perpendicular to that of the first polarizing plate **160**, the light that has been linearly polarized in a direction perpendicular to the polarizing axis of the first polarizing plate **160** is transmitted through the second polarizing plate **170** and is then incident into the transflective film **180**. In case that the transflective film **180** has the refractivity characteristic of the relationship (1), a polarization component, which is polarized in the x-direction parallel to the elongated direction of the transflective film **180**, of the light incident into the transflective film **180** is partially transmitted and reflected, whereas a polarization component, which is polarized in the y-direction perpendicular to the elongated direction, is mostly reflected. Further, in case that the transflective film **180** has the refractive characteristic of the relationship (2), of the light incident into the transflective film **180**, the polarization components polarized in the x- and y-directions are partially transmitted and partially reflected.

Thus, since the linearly polarized light reflected by the transflective film **180** is parallel to the polarizing axis of the second polarizing plate **170**, it is transmitted through the second polarizing plate **170**, and is incident into the liquid crystal layer **130** via the first transparent electrode **112**. The linearly polarized light is transmitted through the liquid crystal layer **130**, whereby it is linearly polarized in the direction parallel to the polarizing axis of the first polarizing plate **160**. Afterwards, the light is transmitted through the first polarizing plate **160**, so that a white image is displayed. Also, the lights that have been transmitted through the transflective film **180** are restored between the transflective film **180** and the backlight **300**, and the restored light is

repeatedly subject to the procedure of a partial reflection and a partial transmission. As a consequence, light loss is reduced and reflectivity and light efficiency are enhanced.

When a maximum pixel voltage is applied (ON) in the reflection mode as shown in FIG. **7**B, light incident from an external source is transmitted through the first polarizing plate **160**, so that the light is linearly polarized in a direction parallel to the polarizing axis of the first polarizing plate **160**. Afterwards, the linearly polarized light is transmitted through the liquid crystal layer **130** without a variation in the polarized state, and is then incident into the second polarizing plate **170**. At this time, since the linearly polarized light is perpendicular to the polarizing axis of the second polarizing plate **170**, the light is all absorbed in the second polarizing plate **170**. Thus, since the linearly polarized light is not reflected by the transflective film **180**, a black image is displayed.

When a pixel voltage is not applied (OFF) in the transmission mode, as shown in FIG. **8**A, light irradiated from the backlight **300** is incident into the transflective film **180**, so that the light is partially transmitted and reflected. In case that the transflective film **180** has the refractive characteristic of the relationship (1), polarization component, which is polarized in the x-direction parallel to the elongated direction of the transflective film **180**, of the light that have been incident into the transflective film **180** is partially transmitted and reflected, whereas polarization components, which are polarized in the y-direction perpendicular to the elongated direction, are mostly reflected. Also, in case that the transflective film **180** has the refractive characteristic of the relationship (2), polarization components, which is polarized in the x- and y-directions, of the light incident into the transflective film **180** is partially transmitted and reflected.

Thus, the light that has been transmitted through the transflective film **180** and the second polarizing plate **170** is linearly polarized in a direction parallel to the polarizing axis of the second polarizing plate **170**. Afterwards, the linearly polarized light is transmitted through the first transparent electrode **112** and the liquid crystal **130**, so that it is linearly polarized in a direction parallel to the polarizing axis of the first polarizing plate **160**. Accordingly, the light linearly polarized in the direction parallel to the polarizing axis of the first polarizing plate **160** is transmitted through the first polarizing plate **160**, so that a white image is displayed. Also, light reflected by the transflective film **180** is restored between the backlight **300** and the transflective film **180**, and then is repeatedly subject to the above steps. Thus, polarization components polarized parallel to the x-direction or polarization components polarized parallel to the x- and y-directions successively are transmitted through the transflective film **180** and are used, so that light loss is reduced and transmissivity and light efficiency are enhanced.

When a maximum pixel voltage is applied (ON) in the transmission mode, as shown in FIG. **8**B, light irradiated from the backlight **300** is incident into the transflective film **180**, so that the incident light is partially transmitted through the transflective film **180** and is partially reflected by the transflective film **180**. The light that has been transmitted through the transflective film **180** is transmitted through the second polarizing plate **170**, so that it is converted into light lineally polarized parallel to the polarizing axis of the second polarizing plate **170**, i.e., a direction perpendicular to the polarizing axis of the first polarizing plate **160**. Afterwards, the linearly polarized light is transmitted through the first transparent electrode **112** and the liquid crystal layer **130** without a variation in the polarized state. Accordingly, the light linearly polarized in the direction perpendicular to the polarizing axis of the first polarizing plate **160** cannot be transmitted through the first polarizing plate **160**, so that a black image is displayed.

FIG. **9** is a schematic view showing a structure of a liquid crystal display device further including a light reflection pattern and optical sheets, and FIG. **10** is a plane view showing the light reflection pattern formed on a light guiding member of FIG. **9**.

Referring to FIG. **9**, a light reflection pattern **322***a* is formed on the reflective-transmissive face **322** of the light guiding member **320** so as to face the luminance controlling member **330**. The light reflection pattern **322***a* partially reflects the light that is incident onto the light reflective-transmissive face **322**, and changes the light path of the light incident onto the light reflective-transmissive face **322** so that a part of the light incident onto the light reflective-transmissive face **322** may proceed toward a light exiting face **323**.

The light reflection pattern **322***a* is formed on the light reflective-transmissive face **322**. For example, the light reflection pattern **322***a* includes a plurality of dots arranged in a matrix shape on the light reflective-transmissive face **322**. Paste mixed with material having a high light reflectivity is printed on the light reflective-transmissive face **322** by a silk screen printing method, so that light reflection pattern **322***a* is formed on the light reflective-transmissive face **322**.

The light reflection pattern **322***a* formed on the light reflective-transmissive face **322** may have various patterns with certain regularity. For example, the dots of the light reflection pattern **322***a* are arranged in a matrix shape on the light reflective-transmissive face **322**, and the size of the respective dots increases in proportion to the distance between each dot and the light incident face **321**. In other words, the dots of the light reflection pattern **322***a* have different sizes such that a dot has a smaller size as it is closer to the light incident face **321**. The size of a dot of the light reflection pattern **322***a* is determined according to the distance between the dot and the light incident face **321**, so that the light reflectivity by the light reflection pattern **322***a* is maintained substantially uniform over the entire surface of the light reflective-transmissive face **322**.

Referring again to FIG. **9**, in the light guiding member **320** of this embodiment, a vertical distance between the light reflective-transmissive face **322** and the light exiting face **323** is substantially uniform. In other words, the light reflective-transmissive face **322** is substantially parallel with the light exiting face **323**.

In another embodiment, however, the light reflective-transmissive face **322** may not be parallel with the light exiting face **323**. Specifically, the vertical distance between the light reflective-transmissive face **322** and the light exiting face **323** decreases in proportion to the distance between a point on the light exiting face **323** (or the light reflective-transmissive face **322**) and the light incident face **321**. Preferably, the vertical distance between the light reflective-transmissive face **322** and the light exiting face **323** decreases gradually. For example, the light exiting face **323** is parallel with the LCD panel, and the light reflective-transmissive face **322** is tilted by a predetermined angle with respect to the light exiting face **323**.

On the other hand, as shown in FIG. **9**, a first optical sheet **340** is installed on the light exiting face **323** of the light guiding member **320** so as to enhance optical characteristic of the light exiting from the light guiding member **320** by

changing optical distribution of the light exiting from the light guiding member **320**. The first optical sheet **340** further includes a first diffusion sheet **342** and a first prism sheet **344**. Specifically, the first diffusion sheet **342** disperses the second light L**2** and a part of the third light L**3** reflected by the luminance controlling member **330**, to thereby provide a uniform luminance distribution. According to one exemplary embodiment of the present invention, at least one first prism sheet **344** is installed on the first diffusion sheet **342**, to thereby enhance a viewing angle of the light exited from the first diffusion sheet **342** by correcting a direction of the light exited from the first diffusion sheet **342**.

In addition, a second optical sheet **350** may be installed between the luminance controlling member **330** and the second LCD panel **200** so as to enhance optical characteristic of the other part of the third light L**3** transmitting the luminance controlling member **330** and then proceeding toward the second LCD panel by changing optical distribution of the other part of the third light L**3**. The second optical sheet **350** may further include a second diffusion sheet **352** and a second prism sheet **354**. Specifically, the second diffusion sheet **352** disperses the other part of the third light L**3**, to thereby provide a uniform luminance distribution. The second prism sheet **354** corrects a direction of the light exited from the second diffusion sheet **352**, to thereby enhance a viewing angle of the light exited from the second diffusion sheet **352**.

Although the first display unit **100** has the same size as the second display unit **200** in the embodiments in FIGS. **1** to **9**, the first display unit **100** may have a different size from the second display unit **200**.

FIG. **11** is a sectional view showing a liquid crystal display device according to another exemplary embodiment of the present invention.

Referring to FIG. **11**, an LCD device **600** includes a first display unit **100**, a second display unit **500** having a different size from the first display unit **100**, and a backlight **300** disposed between the first and second display units **100**, **500**.

A first display area of the first display unit **100** is different from a second display area of the second display unit **500**, and in this embodiment, the first display area of the first display unit **100** is larger than the second display area of the second display unit **500**.

When the first display area of the first display unit **100** is larger than the second display area of the second display unit **500**, optical characteristic of the second display unit **500** varies according to a position of the second display unit **500**.

As shown in FIG. **11**, one end of the second display unit **500** is aligned to the light incident face **321** of the light guiding member **320**. When one end of the second display unit **500** is aligned to the light incident face **321** of the light guiding member **320**, a larger amount of light can be collected at the second display unit **500** compared with when one end of the second display unit **500** is located at other positions.

Although not shown in FIG. **11**, one end of the second display unit **500** can be installed apart from the light incident face **321** by a predetermined distance. For example, the second display unit **500** is disposed at the center portion of the light reflective-transmissive face **322** of the light guiding member **320**. In this case, there is a disadvantage that restriction on luminance exists, but there is an advantage that restriction on installation is reduced. In addition, the other end of the second display unit **500** opposite to the one end of the second display unit **500** may be aligned to a side face, opposite to the light incident face **321**, of the light guiding member **320**.

FIG. **12** is a sectional view showing a liquid crystal display device according to another exemplary embodiment of the present invention, and FIG. **13** is a view showing a first display unit of FIG. **12**.

Referring to FIG. **12**, an LCD device **900** includes a first display unit **700** for displaying first images, a second display unit **200** for displaying second images, and a backlight **800** disposed between the first and second display units **700**, **200**. The first display unit **700** includes a first LCD panel **750**, a first polarizing plate **760**, a second polarizing plate **770** and a transflective film **780**.

Referring to FIG. **13**, the first LCD panel **750** includes a first substrate **710**, a second substrate **720** arranged facing the first substrate **710**, a liquid crystal layer **730** disposed between the first substrate **710** and the second substrate **720**.

Specifically, the first substrate **710** includes a first insulating substrate **711**. On the first insulating substrate **711** is formed a plurality of switching devices, or thin film transistors (TFTs) **712** and a first transparent electrode (or pixel electrode) **714** electrically connected to the TFTs **712**. The TFTs **712** are arranged in a matrix configuration on the first insulating substrate **711**. A gate electrode **712***a* of the TFT **712** is connected a gate line (not shown) extended in a row direction on the first insulating substrate **711**, and a source electrode **712***b* of the TFT **712** is connected a data line (not shown) extended in a column direction on the first insulating substrate **711**. A drain electrode **712***c* of the TFT **712** is electrically connected the first transparent electrode **714** made of a conductive oxidation film such as indium tin oxide (ITO).

An organic insulating layer **713** is formed between the TFT **712** and the first transparent electrode **714**. The organic insulating layer **713** includes a contact hole **713***a* that exposes the drain electrode **712***c*. The organic insulating layer **713** insulates the TFT **712** and the first transparent electrode **714**, and simultaneously allows the first transparent electrode **714** to contact only the drain electrode **712***c*.

The second substrate **720** includes a second insulating substrate **721**. An RGB color filter **722**, a black matrix (BM) layer **723** and a second transparent electrode **724** are formed on the second insulating substrate **721**. On the second insulating substrate **721**, the RGB color filter **722** is arranged in a matrix configuration corresponding to the pixel electrode **714** formed on the first insulating substrate **711**. The black matrix layer **723** is formed between the RGB color filter **722** on the second insulating substrate **721** so as to enhance contrast ratio (C/R). In addition, a second transparent electrode **724** is formed on the entire surface of the second insulating substrate on which the RGB color filter **722** is formed.

The first transparent electrode **714** of the first substrate **710** is arranged facing the second transparent electrode **724** of the second substrate **720**. A liquid crystal layer **730** is made of 90° twisted TN (Twisted Nematic) liquid crystal composition, and the liquid crystal **730** is disposed between the first substrate **710** and the second substrate **720**.

On an upper surface of the first LCD panel **750** is disposed a first polarizing plate **760**, and a second polarizing plate **770** is disposed on a lower surface of the first LCD panel **750**. Under the second polarizing plate **770** is disposed a transflective film **780** including at least two transparent layers, which have different refractivity index values from each other and are alternately stacked on the second polarizing plate **770**. The transflective film **780** partially reflects and partially transmits light incident thereto. Accordingly, the LCD device can display images through a reflection light path (R) and a transmission light path (T).

Referring again to FIG. **12**, the second display unit **200** includes a second LCD panel **250**, a third polarizing plate **260** and a fourth polarizing plate **270**. The second LCD panel includes a third substrate **210**, a fourth substrate **220** arranged facing the third substrate **210**, and a second liquid crystal layer **230** disposed between the third substrate **210** and the fourth substrate **220**. On an upper surface of the second LCD panel **250** is disposed a third polarizing plate **260**, and a fourth polarizing plate **270** is disposed on a lower surface of the second LCD panel **250**.

Although not shown in FIG. **12**, the second LCD panel **250** can be embodied same as the first LCD panel **750** of FIG. **13**.

A backlight **800** is disposed between the first and second display units **700**, **200**. The backlight **800** generates light and provides the first and second display units **700**, **200** with the generated light.

The backlight **800** includes a lamp unit **820**, a first light guiding member **820**, a second light guiding member **830**, and a luminance controlling member **840** disposed between the first and second light guiding members **820**, **830**. The lamp unit **810** includes a lamp **811** for generating light, and a lamp reflector **812** for reflecting the light generated from the lamp **811** to provide the first and second light guiding members **820**, **830** with the light generated from the lamp **811**. A part of the light generated from the lamp **811**, or the first light L**1**, is incident onto the first light guiding member **820**, and the other part of the light generated from the lamp **811**, or the second light L**2**, is incident onto the second light guiding member **830**.

The first light guiding member **820** includes four first side faces including a first light incident face **821**, a first light reflective-transmissive face **822** and a first light exiting face **823**. The first light exiting face **823** faces the first light reflective-transmissive face **822**.

The first light L**1** incident into the first light guiding member **820** through the first light incident face **821** is divided to proceed toward the first and the second display units **700**, **200** by the following path. The first light guiding member **820** divides the first light L**1** to exit third and fourth lights L**3**, L**4**. The first light guiding member **820** exits the third light L**3** or a part of the first light L**1** toward the first display unit **700**, and exits the fourth light L**4** or the other part of the first light L**1** toward the second display unit **200**. Specifically, the third light L**3** includes light exiting directly from the first light exiting face **823** and light being reflected by the first light reflective-transmissive face **822** to exit through the first light exiting face **823**. The fourth light L**4** passes through the first light reflective-transmissive face **822** to proceed toward the second display unit **200**.

The second light guiding member **830** is disposed between the first and second display units **700**, **200**, and more specifically is disposed in the vicinity of the first reflective-transmissive face **822**. The second light guiding member **830** includes four second side faces including a second light incident face **831** onto which the second light L**2** is incident, a second light reflective-transmissive face **832** and a second light exiting face **833**. The second light exiting face **833** faces the second light reflective-transmissive face **832**.

The second light L**2** incident into the second light guiding member **830** through the second light incident face **831** is divided to proceed toward the first and second display units **700**, **200** by the following path. The second light guiding member **830** divides the second light L**2** to exit fifth and sixth lights L**5**, L**6**. The second light guiding member **830** exits the sixth light L**6** or a part of the second light L**2** toward the first display unit **700**, and exits the fifth light L**5** or the other part of the second light L**2** toward the second display unit **200**. Specifically, the fifth light L**5** includes light exiting directly from the second light exiting face **833** and light being reflected by the second light reflective-transmissive face **832** to exit through the second light exiting face **833**. The sixth light L**6** passes through the second light reflective-transmissive face **832** to proceed toward the first display unit **700**.

A luminance controlling member **840** is installed between the first light guiding member **820** and the second light guiding member **830**. The luminance controlling member **840** may have a sheet shape or a plate shape thicker than the sheet shape, and is made of, for example, polyethylene terephthalate (PET) treated by foaming agent.

The fourth light L**4**, which passes through the first light reflective-transmissive face **822** of the first light guiding member **820**, and the sixth light L**6**, which passes through the second light reflective-transmissive face **832** of the second light guiding member **830**, reach the luminance controlling member **840**. The luminance controlling member **840** reflects a part of the fourth light L**4** to provide the first display unit **700** with the reflected part of the fourth light L**4** through the first light guiding member **820**, and transmits the other part of the fourth light L**4** to provide the second display unit **200** with the other part of the fourth light L**4**. In addition, the luminance controlling member **840** reflects a part of the sixth light L**6** to provide the second display unit **200** with the reflected part of the sixth light L**6** through the second light guiding member **830**, and transmits the other part of the sixth light L**6** to provide the first display unit **700** with the other part of the sixth light L**6**.

A first luminance at the first display unit **700** and a second luminance at the second display unit **200** are precisely controlled by controlling the light reflectivity and the light transmissivity of the luminance controlling member **840**. Thus, a ratio of the first luminance to the second luminance can be precisely controlled by controlling the light reflectivity and the light transmissivity of the luminance controlling member **840**.

In this embodiment, the first light guiding member **820** is a flat type light guiding plate, in which a vertical distance between the first light reflective-transmissive face **822** and the first light exiting face **823** is substantially uniform. The second light guiding member **830** is also a flat type light guiding plate. However, the first and second light guiding members may have a wedge shape, in which the vertical distance between the light reflective-transmissive face and the light exiting face varies gradually.

FIG. **14** is a schematic view showing a structure of the liquid crystal display device of FIG. **12** further including light reflection patterns and optical sheets.

Referring to FIG. **14**, a first light reflection pattern **822*a*** is formed on the first reflective-transmissive face **822** of the first light guiding member **820**, and a second light reflection pattern **832*a*** is formed on the second reflective-transmissive face **832** of the second light guiding member **830**. For example, the first and second light reflection patterns **822*a***, **832*a*** include a plurality of dots arranged in a matrix shape.

The size of the respective dots of the first light, reflection pattern **822*a*** successively increases in proportion to the distance between a dot of the first light reflection pattern **822*a*** and the first light incident face **821**. The size of the respective dots of the second light reflection pattern **832*a*** successively increases in proportion to the distance between a dot of the second light reflection pattern **832*a*** and the second light incident face **831**.

On the other hand, as shown in FIG. **14**, the backlight **800** further includes a first optical sheet **850** and a second optical sheet **860**. Specifically, the first optical sheet **850** is installed between the first display unit **700** and the first light exiting face **823**, and the second optical sheet **860** is installed between the second display unit **200** and the second light exiting face **833**.

The first optical sheet **850** enhances a viewing angle of a part of the third light L**3** and a part of the fourth light L**4**, and diffuses the part of the third light L**3** and the part of the fourth light L**4** so as to provide a uniform luminance distribution. The second optical sheet **860** enhances a viewing angle of a part of the fifth light L**5** and a part of the sixth light L**6**, and diffuses the part of the fifth light L**5** and the part of the sixth light L**6** so as to provide a uniform luminance distribution.

FIG. **15** is a sectional view showing a liquid crystal display device according to another exemplary embodiment of the present invention.

Referring to FIG. **15**, an LCD device **1200** includes a first display unit **700**, a second display unit **1000** having a different size from the first display unit **700**, and a backlight **1100** disposed between the first and second display units **700**, **1000**.

In this embodiment, a first display area of the first display unit **700** is larger than a second display area of the second display unit **1000**, and the first and second light guiding members **1120**, **1130** each have a size fit to the first and the second display areas, respectively. The surface area of the first light guiding member **1120** is larger than that of the second light guiding member **1130**. In another embodiment, however, the first display area of the first display unit may be smaller than the second display area of the second display unit.

A luminance controlling member **1140** is disposed between the first and second light guiding members **1120**, **1130**. The surface area of the luminance controlling member **1140** corresponds in its size to that of the first light guiding member **1120**, or corresponds to the largest one of the surface areas of the first and second light guiding members **1120**, **1130**.

As shown in FIG. **15**, a first light reflection pattern **1122***a* is formed on a first reflective-transmissive face **1122** of the first light guiding member **1120**, and a second light reflection pattern **1132***a* is formed on the second reflective-transmissive face **1132** of the second light guiding member **1130**. In this embodiment, the first and second light reflection patterns **1122***a*, **1132***a* each include a plurality of dots arranged in a matrix shape. Since the surface area of the first light guiding member **1120** is larger than that of the second light guiding member **1130**, a configuration of the first light reflection pattern **1122***a* formed on the first reflective-transmissive face **1122** differs from the configuration of the second light reflection pattern **1132***a* formed on the second reflective-transmissive face **1132**.

For example, the size of the respective dots of the first (or second) light reflection pattern **1122***a* (**1132***a*) successively increases in proportion to the distance between a dot of the first (or second) light reflection pattern **1122***a* (**1132***a*) and a first (or second) light incident face **1121** (**1131**), but the size of the respective dots of the first light reflection pattern **1122***a* differs from the size of the respective dots of the second light reflection pattern **1132***a*. In other words, the dots of the second reflection pattern **1132***a* have sizes with a higher ratio of a size change to a unit distance change than those of the dots of the first reflection pattern **1122***a*.

Although not shown in FIG. **15**, the backlight **1100** may further include a first optical sheet and a second optical sheet. The first optical sheet may be installed between the first display unit **700** and the first light exiting face **1123**, and the second optical sheet may be installed between the second display unit **1000** and the second light exiting face **1133**. Preferably, the surface areas of the first and second optical sheets are in their size to those of the first and second light guiding members **1120**, **1130**, respectively.

FIG. **16** is a sectional view showing a liquid crystal display device according to another exemplary embodiment of the present invention.

Referring to FIG. **16**, an LCD device includes a first display unit **700**, a second display unit **1300**, and a backlight **800** disposed between the first and second display units **700**, **1300**.

The first display unit **700** includes a first LCD panel **750**, a first polarizing plate **760**, a second polarizing plate **770** and a first transflective film **780**. The second display unit **1300** includes a second LCD panel **1350**, a third polarizing plate **1360**, a fourth polarizing plate **1370** and a second transflective film **1380**.

Under the second polarizing plate **770**, or between the second polarizing plate **770** and the backlight **800**, is disposed a first transflective film **780** including at least two transparent layers having different refractivity index values from each other, i.e., a first layer and a second layer alternately stacked to form more than or equal to two layers. The first transflective film **780** partially reflects and partially transmits light incident thereto. Accordingly, the first display unit **700** displays images using the reflected light and the transmitted light.

Between the third polarizing plate **1360** and the backlight **800**, is disposed a second transflective film **1380** including at least two transparent layers having different refractivity index values from each other, i.e., a first layer and a second layer alternately stacked to form more than or equal to two layers. The second transflective film **1380** partially reflects and partially transmits light incident thereto. Accordingly, the second display unit **1300** displays images using the reflected light and the transmitted light.

While the present invention has been described in detail, it should be understood that various changes, substitutions and alterations can be made hereto without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A dual liquid crystal display device comprising:

a first display unit including:

a first liquid crystal display panel having a first substrate, a second substrate and a first liquid crystal layer between the first and second substrates, and

a transflective film disposed under the first liquid crystal display panel, so that the transflective film partially reflects and partially transmits an incident light incident onto the transflective film;

a second display unit including a second liquid crystal display panel having a third substrate, a fourth substrate and a second liquid crystal layer between the third and fourth substrates; and

a light supplying unit disposed between the first and second display units, the light supplying unit generating a first light to provide the first display unit with a first part of the first light and the second display unit with a second part of the first light, and the light supplying unit controlling an amount of the first and

second parts of the first light to regulate a contrast ratio of a luminance between the first and second display units.

2. The dual liquid crystal display device of claim **1**, wherein the first display unit further includes a first polarizing plate disposed on the first liquid crystal display panel and a second polarizing plate disposed between the first liquid crystal display panel and the transflective film, and the transflective film is integrally formed with the second polarizing plate.

3. The dual liquid crystal display device of claim **1**, wherein the first display unit further includes a first polarizing plate disposed on the first liquid crystal display panel and a second polarizing plate disposed between the first liquid crystal display panel and the transflective film, and the transflective film is formed separate from the second polarizing plate to have a sheet shape.

4. The dual liquid crystal display device of claim **1**, wherein the transflective film has an anisotropy characteristic having transmissivity and reflectivity varying depending on a polarized state and a direction of the incident light.

5. The dual liquid crystal display device of claim **4**, wherein the transflective film comprises a plurality of layers in which a first layer and a second layer each having a different refractivity index are alternately stacked; and

when the transflective film has a film thickness in z-dirction and a film plane in x-y plane parallel with a surface of the transflective film, the first layer and the second layer respectively have three main refractive indexes of n_x, n_y and n_z that satisfy the following relationships:

$$n1_x=n1_z\neq n1_y;$$

$$n2_x=n2_y=n2_z;$$

$$n1_x\neq n2_x;$$

$$n1_y\neq n2_y;\text{ and}$$

$$|n1_x-n2_x|<|n1_y-n2_y|$$

in which n**1**x, n**1**y and n**1**z denote main refractive indexes of the first layer in x-direction, y-direction and z-direction, respectively, and n**2**x, n**2**y and n**2**z denote main refractive indexes of the second layer in x-direction, y-direction and z-direction, respectively.

6. The dual liquid crystal display device of claim **1**, wherein the transflective film has isotropic transmission and reflection characteristics independent of a polarized state and a direction of the incident light.

7. The dual liquid crystal display device of claim **6**, wherein the transflective film comprises a plurality of layers in which a first layer and a second layer each having a different refractivity index are alternately stacked; and

when to transflective film has a film thickness in z-direction and a film plane in x-y plane parallel with a surface of the transflective film, the first layer and the second layer respectively have three main refractive indexes of n_x, n_y and n_z that satisfy the following relationships:

$$n1_x=n1_y=n1_z;\text{ and}$$

$$n2_x=n2_y=n2_z\neq n1,$$

in which n**1**x, n**1**y and n**1**z denote main refractive indexes of the first layer in x-direction, y-direction and z-direction, respectively, and n**2**x, n**2**y and n**2**z denote main refractive indexes of the second layer in x-direction, y-direction and z-direction, respectively.

8. The dual liquid crystal display device of claim **1**, wherein a reflection path and a transmission path are provided in the first display unit, light traveling through the reflection pat being incident onto a front face of the first liquid crystal display panel and reflected by the transflective film toward the first liquid crystal display panel to exit through the front face of the first liquid crystal display panel, and light traveling through the transmission path being incident onto a rear face of the first liquid crystal display panel from the light supplying unit after passing through the transflective film to exit through the first liquid crystal display panel.

9. The dual liquid crystal display device of claim **1**, wherein the transflective film comprises a first transflective layer and a second transflective layer, the first transflective layer having transmissivity and reflectivity varying depending on a polarized state and a direction of the incident light, the second transflective layer having isotropic transmission and reflection characteristics independent of the polarized state and the direction of the incident light.

10. The dual liquid crystal display device of claim **1**, wherein the first display unit further includes a light scattering layer.

11. The dual liquid crystal display device of claim **1**, wherein the transflective film comprises two anisotropic transflective layers each having a transmissivity and a reflectivity that vary according to a polarized state and a direction of the incident light.

12. The dual liquid crystal display device of claim **10**, wherein the first display unit further includes a first polarizing plate disposed on the first liquid crystal display panel and a second polarizing plate disposed between the first liquid crystal display panel and the transflective film, and the light scattering layer is disposed between the first substrate and the second polarizing plate.

13. The dual liquid crystal display device of claim **10**, wherein the first display unit further includes a first polarizing plate disposed on the first liquid crystal display panel and a second polarizing plate disposed between the first liquid crystal display panel and the transflective film, and the light scattering layer is disposed between the second substrate and the first polarizing plate.

14. The dual liquid crystal display device of claim **10**, wherein the first display unit further includes a first polarizing plate disposed on the first liquid crystal display panel and a second polarizing plate disposed between the first liquid crystal display panel and the transflective film, and the light scattering layer is disposed between the second polarizing plate and the transflective film.

15. The dual liquid crystal display device of claim **1**, wherein the second display unit further includes:

a third polarizing plate disposed on a first surface of the second liquid crystal display panel; and

a fourth polarizing plate disposed on a second surface of the second liquid crystal display panel.

16. The dual liquid crystal display device of claim **1**, wherein the light supplying unit comprises:

a light source for generating the first light;

a light guiding member for receiving the first light, providing the first display unit with the first part of the first light as a second light, and providing the second display unit with the second part of the first light as a third light; and

a luminance controlling member for reflecting a first part of the third light and transmitting a second part of the third light to control the contrast ratio of the luminance between the first and the second display units.

17. The dual liquid crystal display device of claim **16**, wherein the light guiding member comprises:

a light incident face for receiving the first light;

a light reflective-transmissive face for reflecting the second light toward the first display unit and transmitting the third light toward the second display unit; and

a light exiting face, being opposite to the light reflective-transmissive face, for exiting the second light.

18. The dual liquid crystal display device of claim **17**, wherein a light reflection pattern having a plurality of dots is formed on the light reflective-transmissive face, and sizes of the dots are different such that a dot farther apart from the light incident face is larger than a dot closer to the light incident face in proportion to a distance between a corresponding dot and the light incident face.

19. The dual liquid crystal display device of claim **16**, wherein the luminance controlling member has a sheet shape.

20. The dual liquid crystal display device of claim **17**, further comprising an optical sheet for changing an optical distribution of the second light so as to enhance an optical characteristic of the second light, the optical sheet being disposed between the light guiding member and to transflective film.

21. The dual liquid crystal display device of claim **1**, wherein the luminance measured at the first display unit is higher than the luminance measured at the second display unit.

22. The dual liquid crystal display device of claim **1**, wherein a surface area of the first liquid crystal display panel has a size substantially equal to a surface area of the second liquid crystal display panel.

23. The dual liquid crystal display device of claim **1**, wherein a surface area of the first liquid crystal display panel is larger than a suffice area of the second liquid crystal display panel.

* * * * *

Exhibit 2

US006771344B2

(12) United States Patent
Lyu et al.

(10) Patent No.: **US 6,771,344 B2**
(45) Date of Patent: **Aug. 3, 2004**

(54) **LIQUID CRYSTAL DISPLAY HAVING WIDE VIEWING ANGLE**

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(73) Assignee: **Samsung Electronics Co., Ltd.**, Suwon (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/877,481**

(22) Filed: **Jun. 8, 2001**

(65) **Prior Publication Data**

US 2001/0028414 A1 Oct. 11, 2001

Related U.S. Application Data

(62) Division of application No. 09/087,408, filed on May 29, 1998, now Pat. No. 6,285,431.

(30) **Foreign Application Priority Data**

May 29, 1997 (KR) 97-21708
Aug. 25, 1997 (KR) 97-40665

(51) **Int. Cl.**[7] **G02F 1/1343**; G02F 1/1337
(52) **U.S. Cl.** **349/143**; 349/129; 349/139; 349/141

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Primary Examiner—Tarifur R. Chowdhury
(74) *Attorney, Agent, or Firm*—McGuireWoods LLP

(57) **ABSTRACT**

Apertures are formed in the common electrode or in the pixel electrode of a liquid crystal display to form a fringe field. Storage capacitor electrodes are formed at the position corresponding to the apertures to prevent the light leakage due to the disclination caused by the fringe field. The apertures extend horizontally, vertically or obliquely. The apertures in adjacent pixel regions may have different directions to widen the viewing angle.

8 Claims, 18 Drawing Sheets

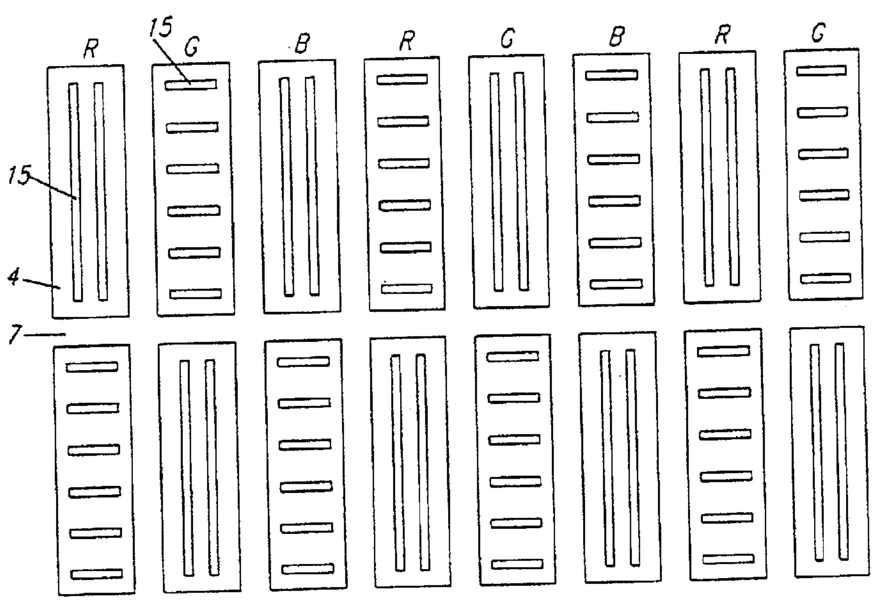


FIG.1A

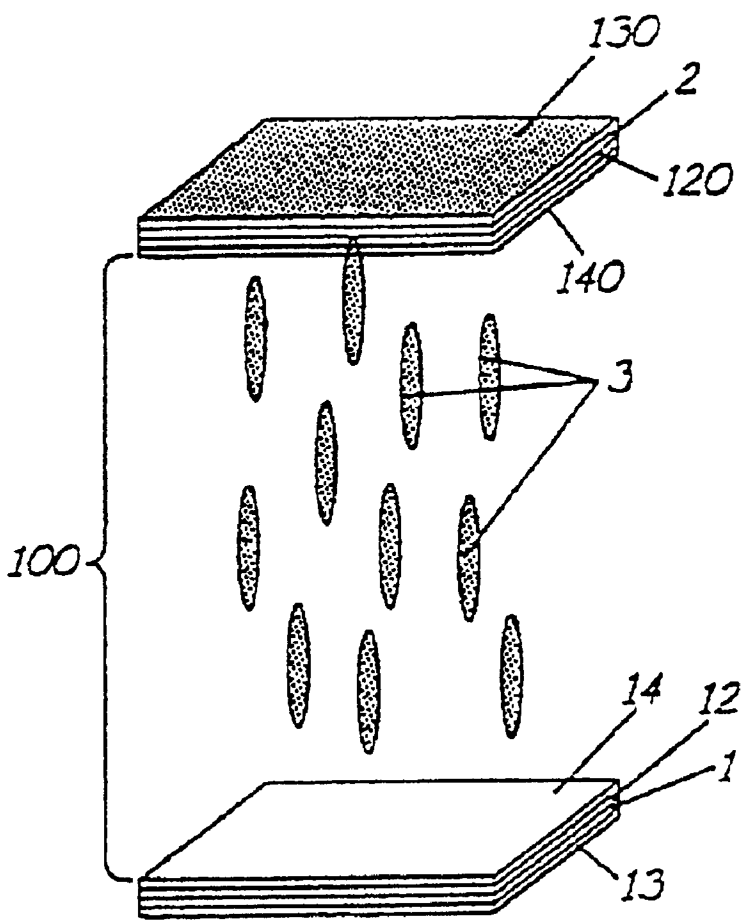


FIG. 1B

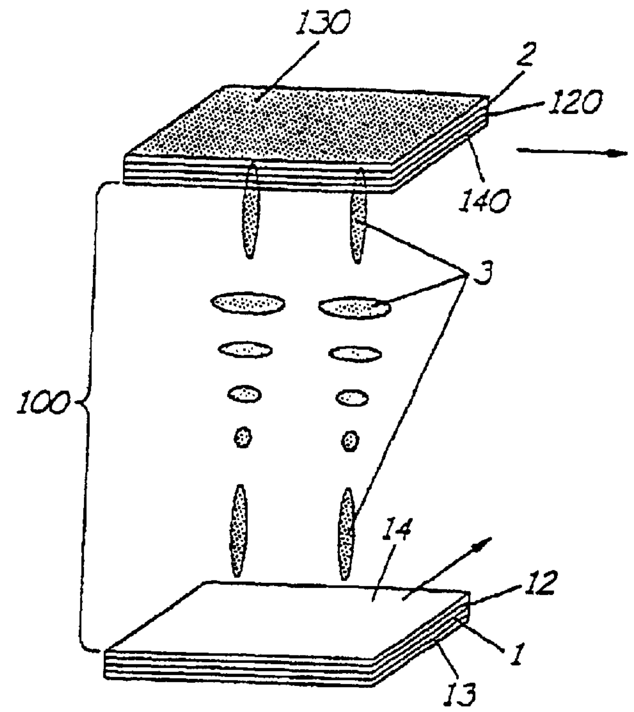


FIG. 2

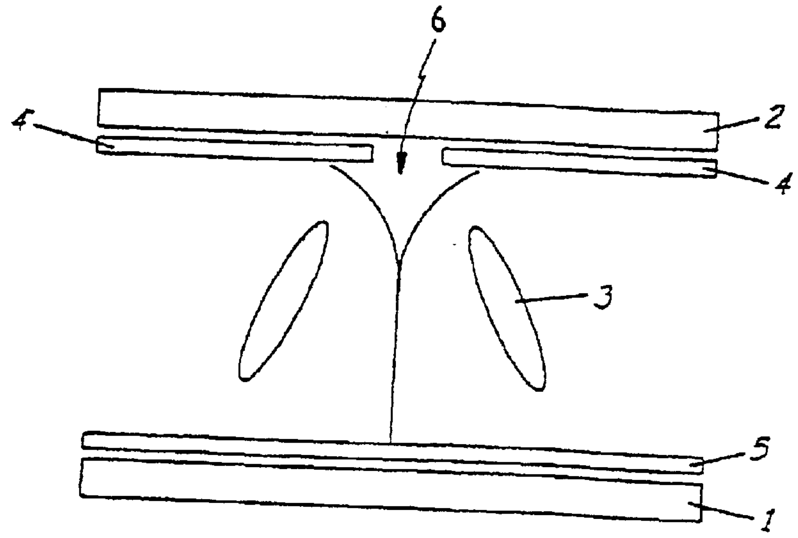


FIG.3

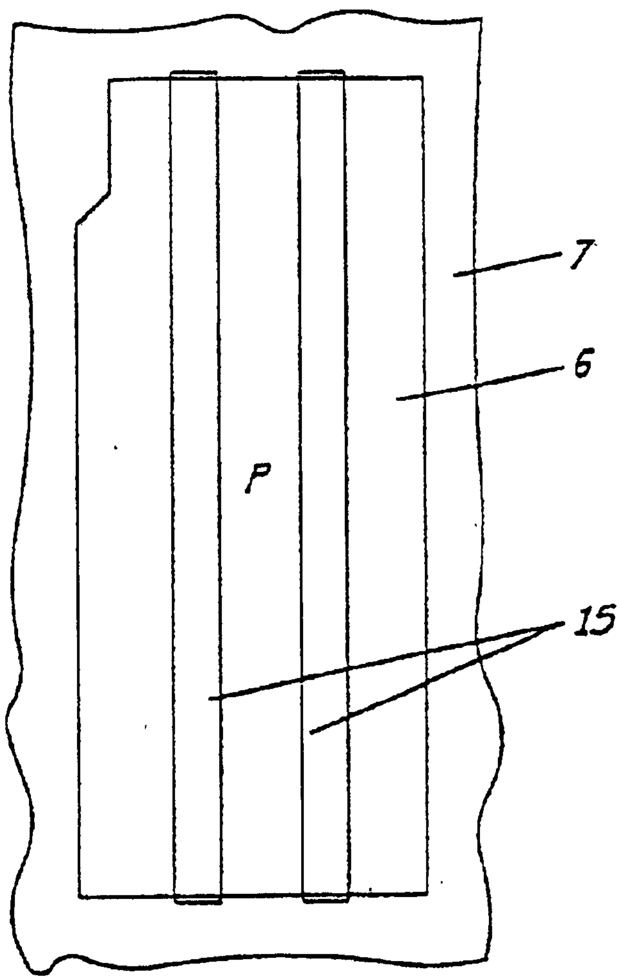


FIG.4

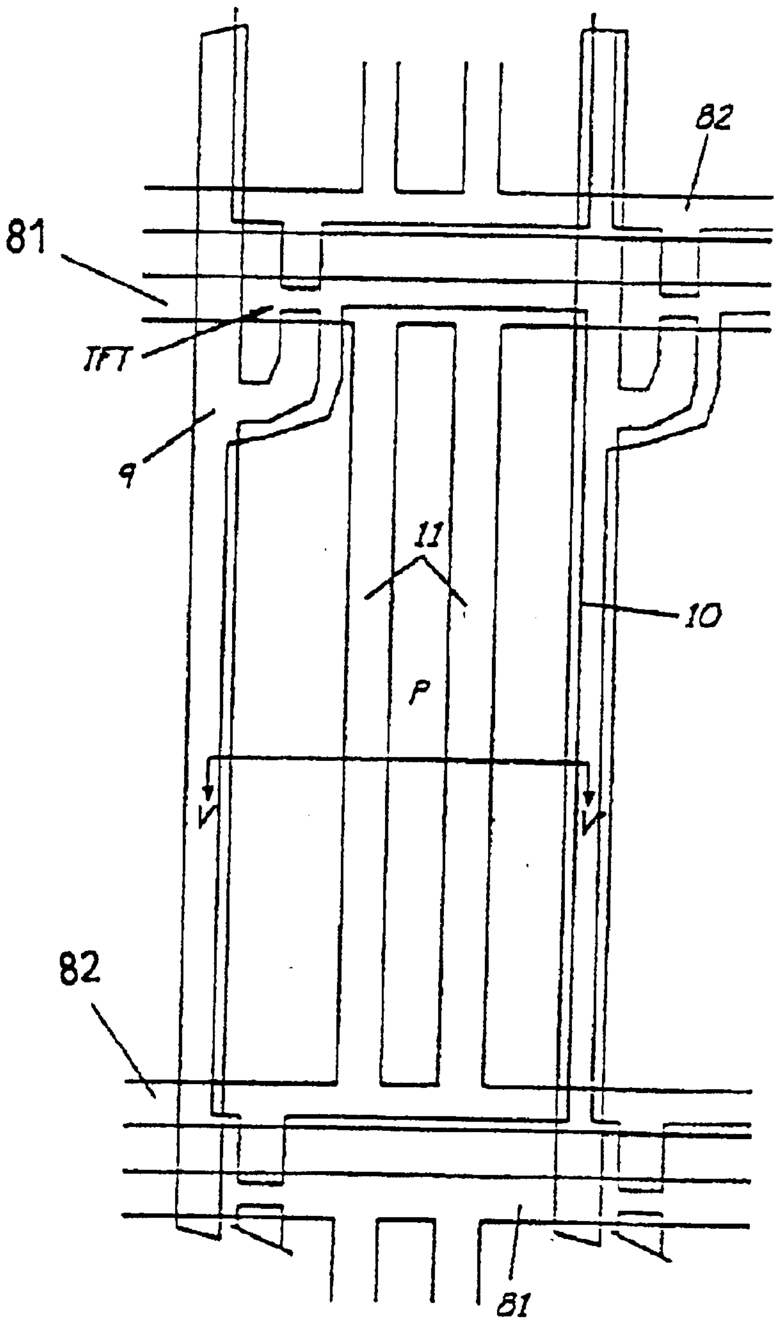


FIG.5

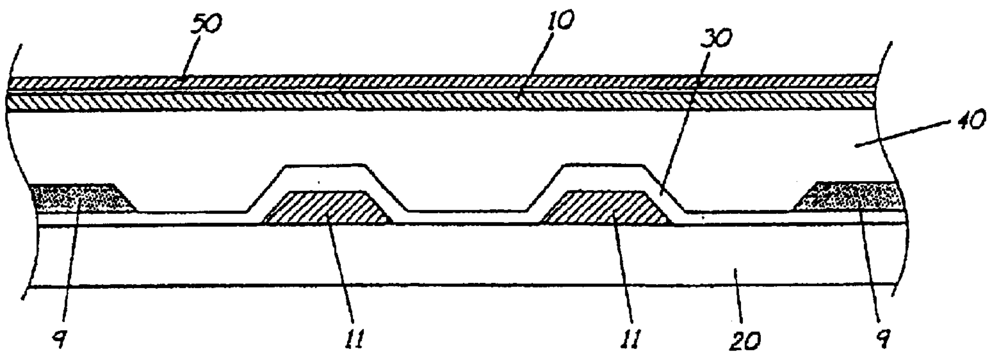


FIG. 6

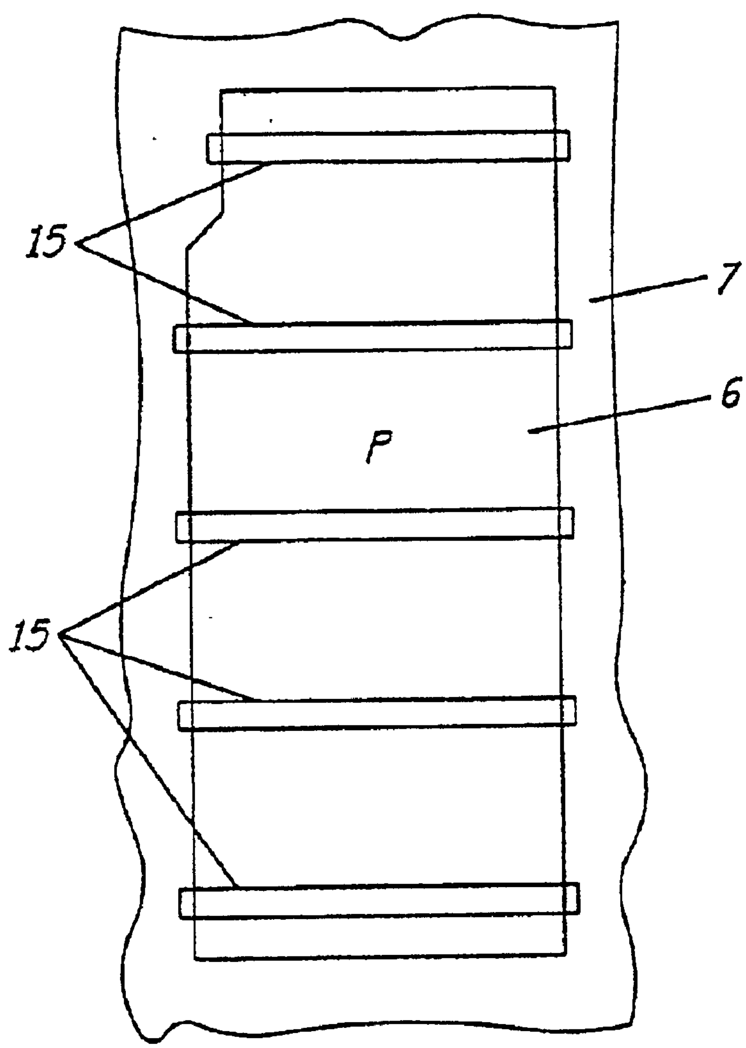


FIG.7

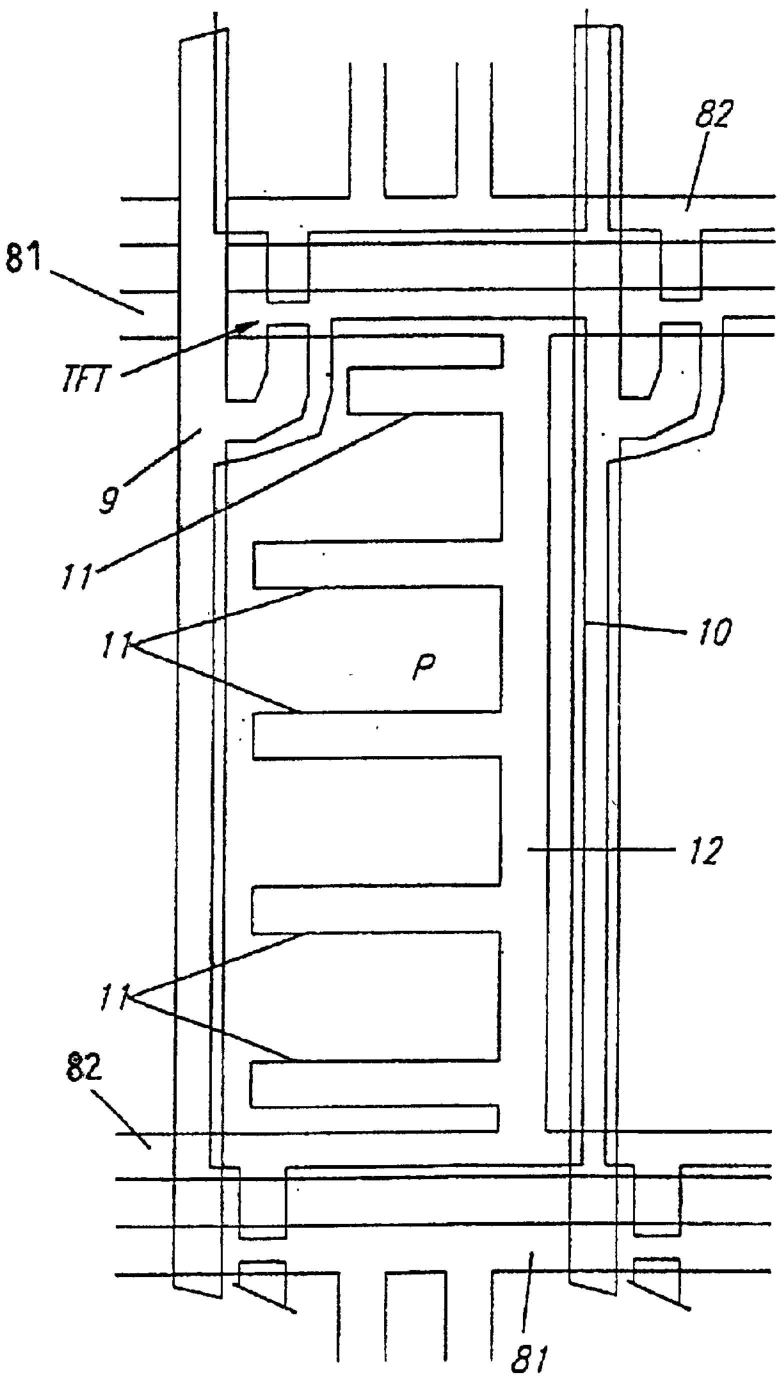


FIG. 8

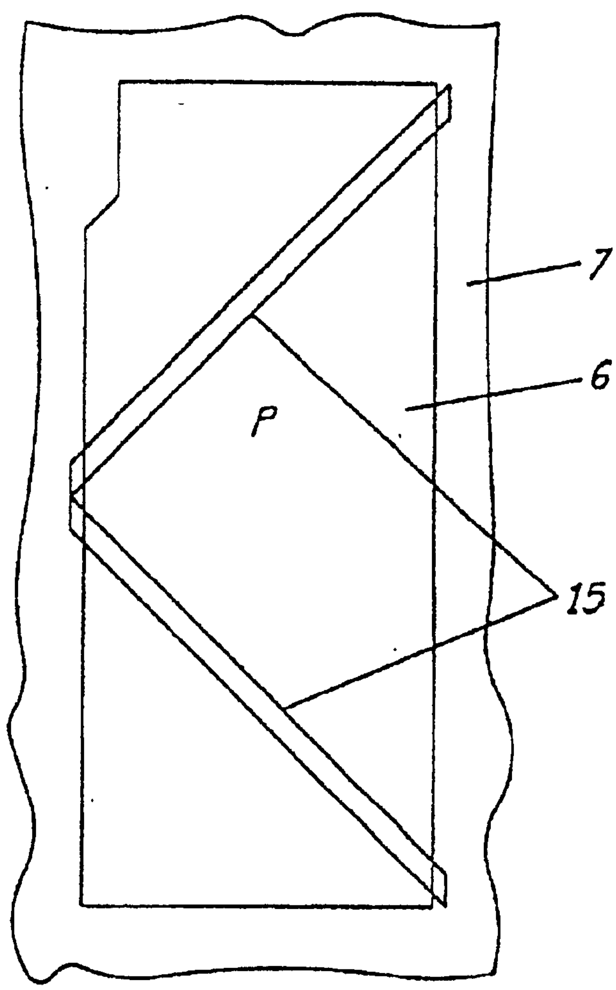


FIG. 9

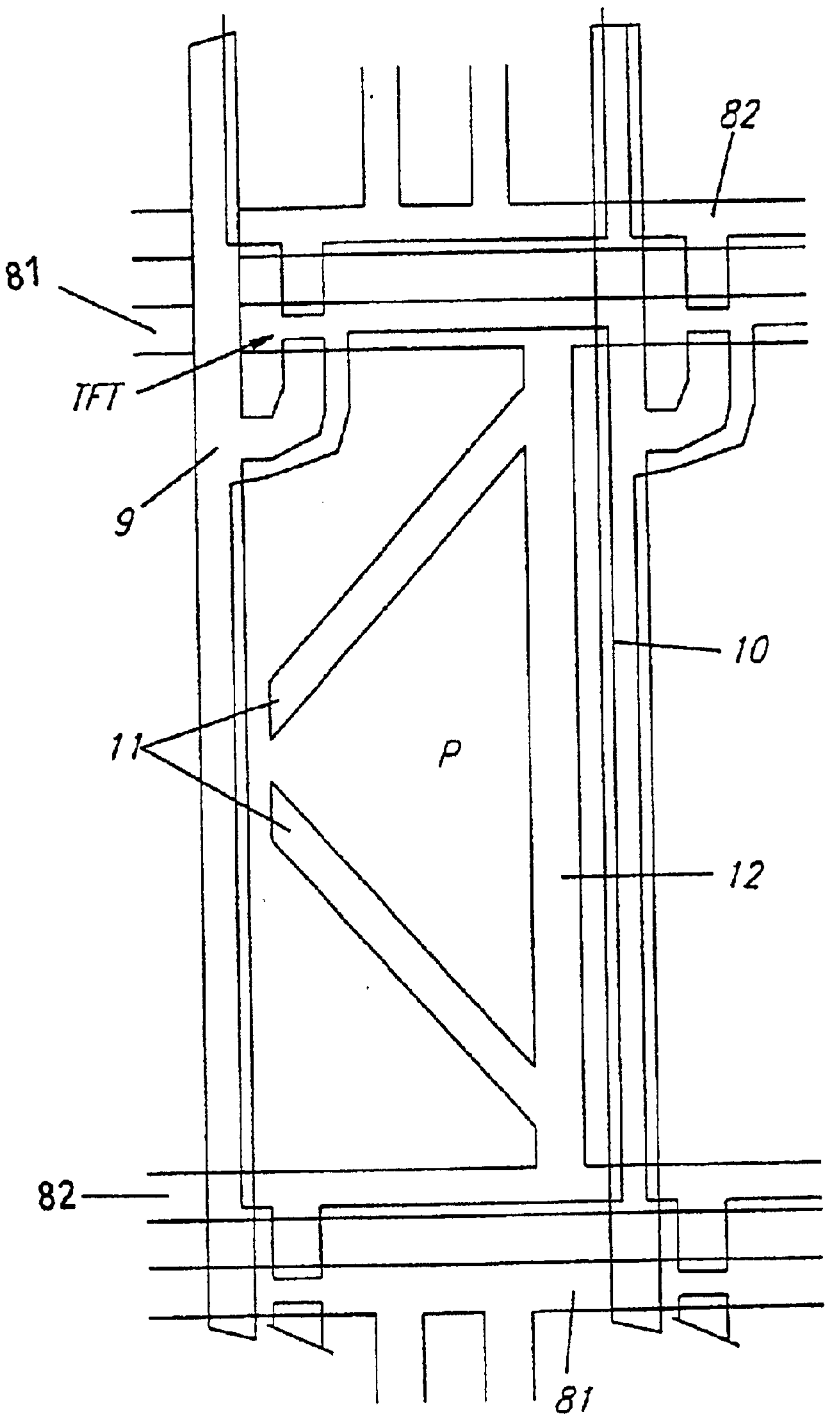


FIG.10

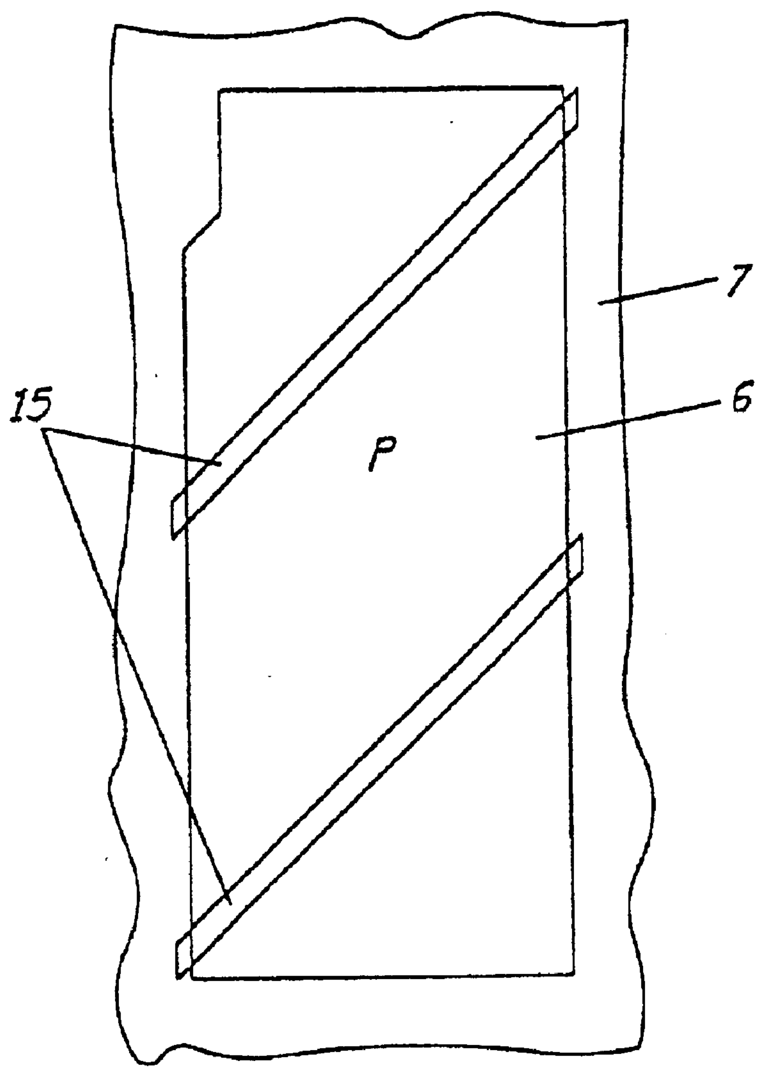


FIG. 11

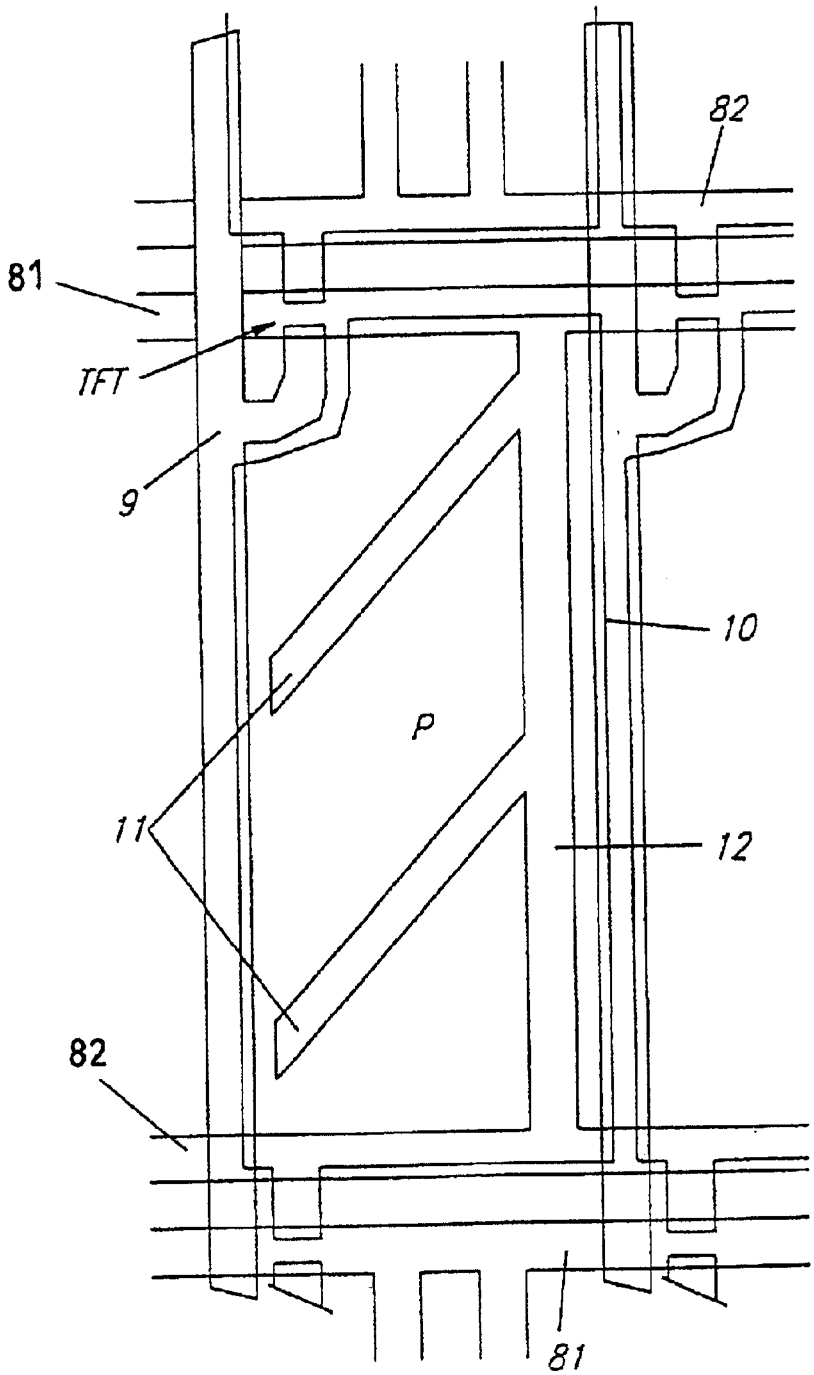


FIG. 12

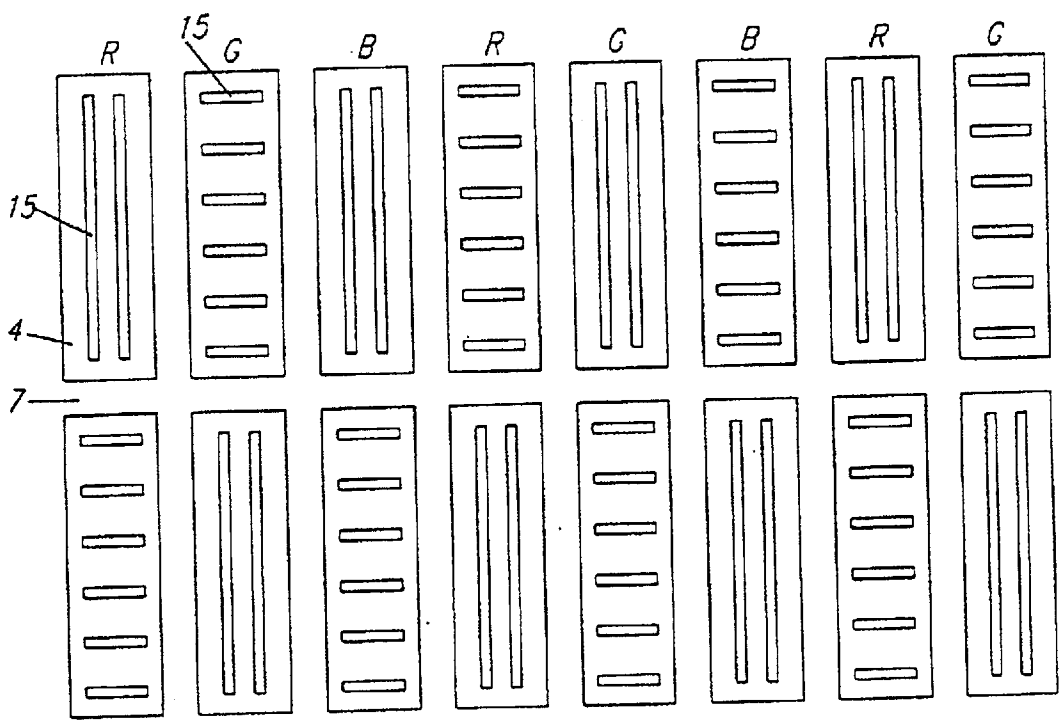


FIG. 13A

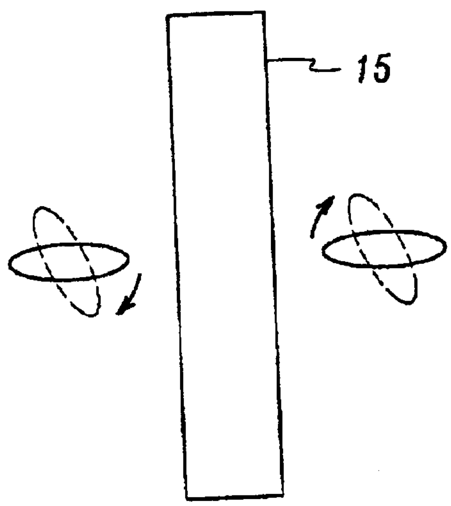


FIG. 13B

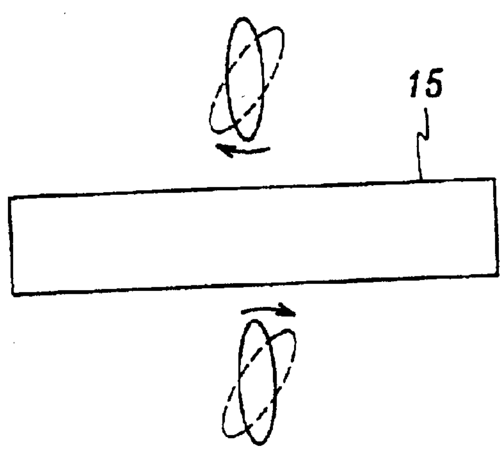


FIG.14

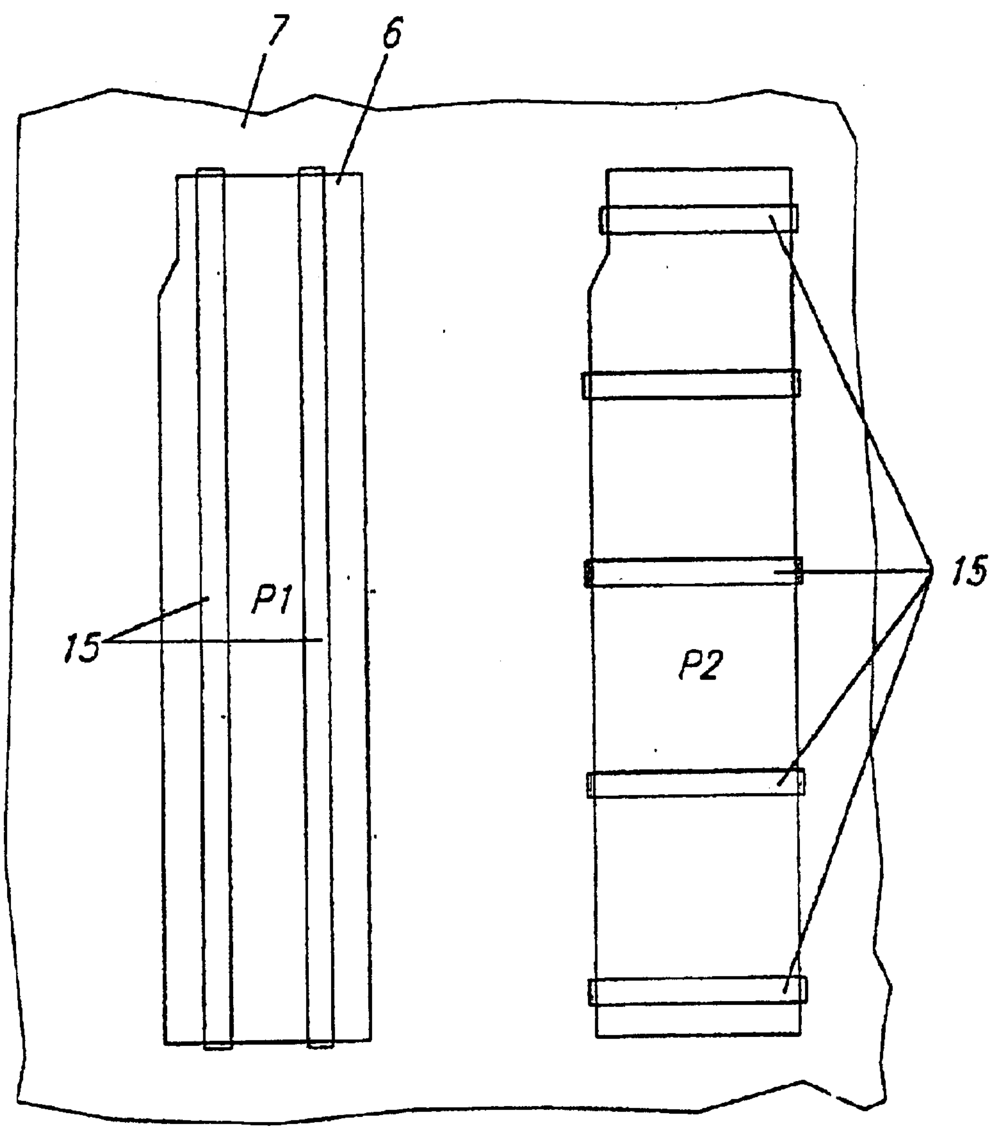


FIG.15

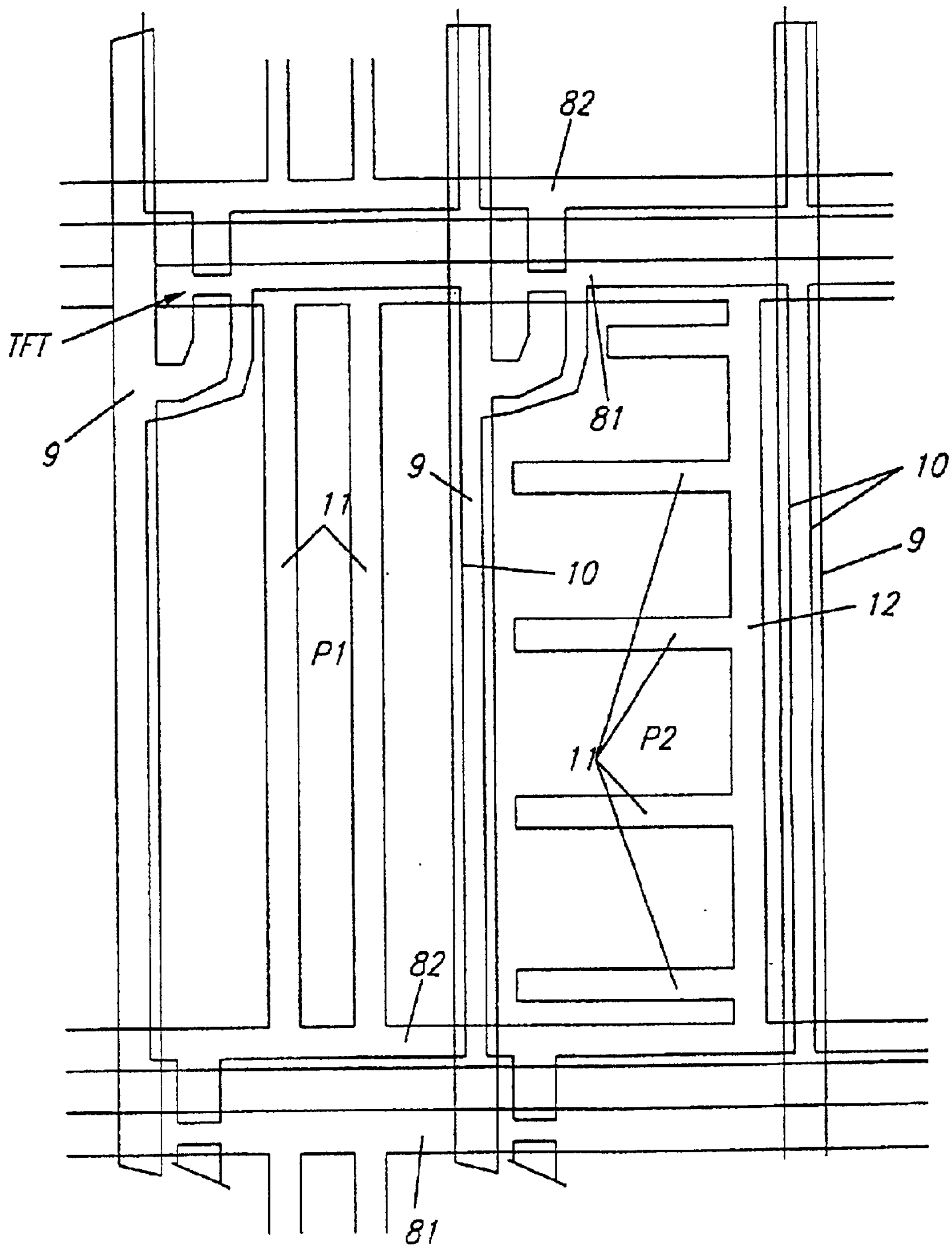


FIG.16

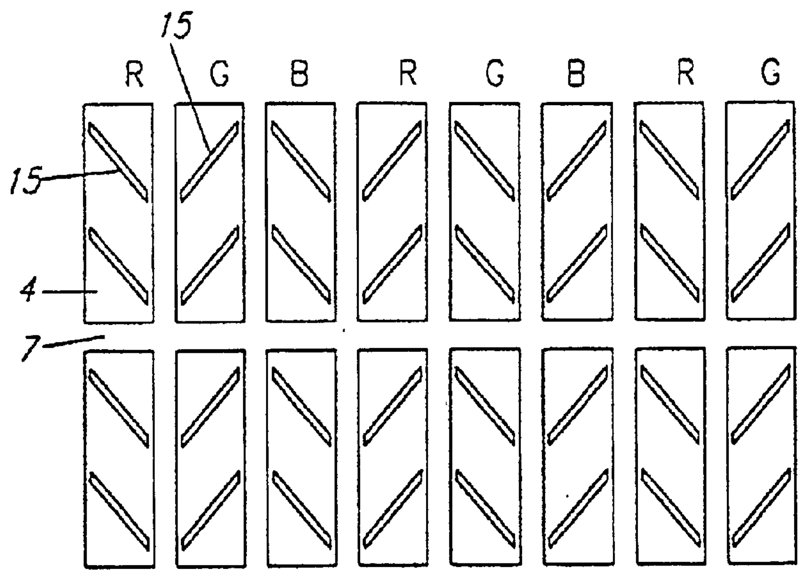


FIG.17

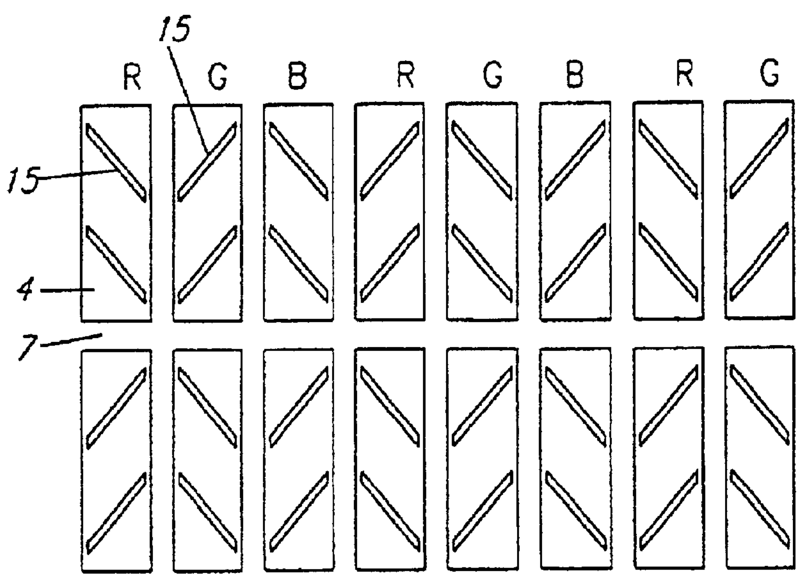


FIG.18

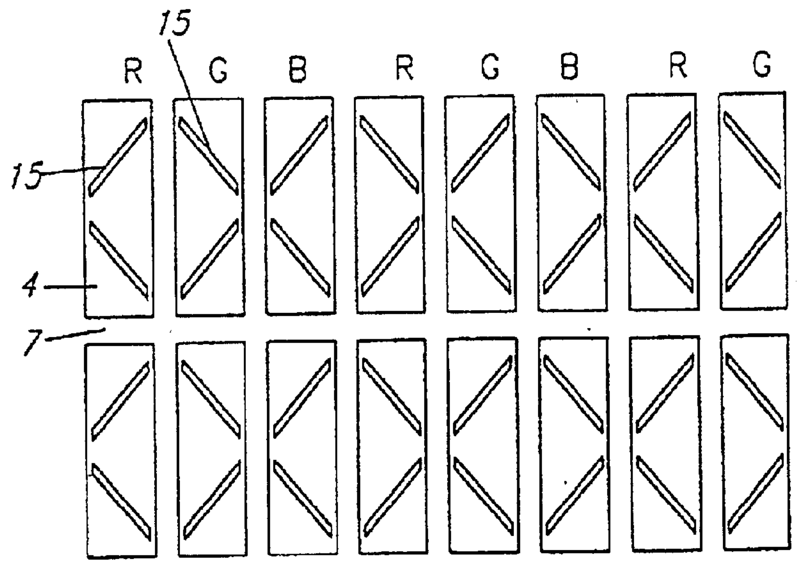


FIG.19

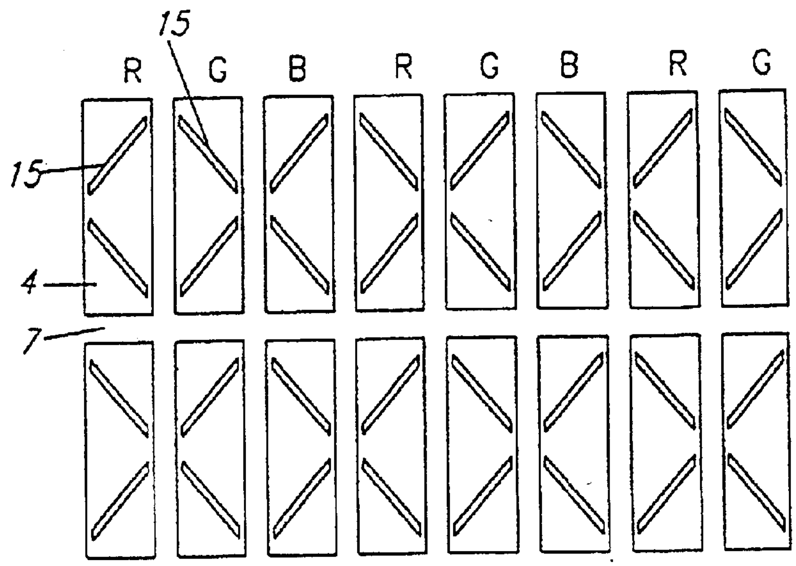
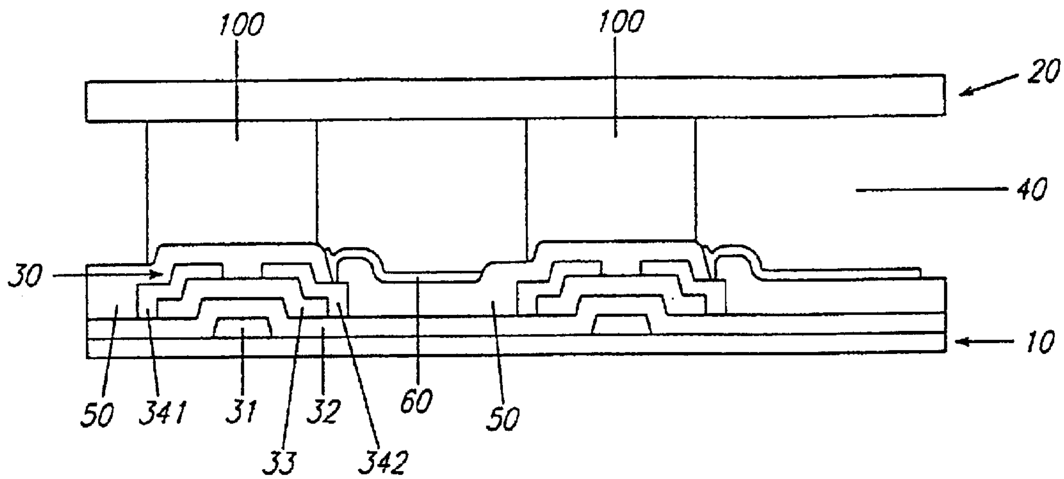


FIG.20



LIQUID CRYSTAL DISPLAY HAVING WIDE VIEWING ANGLE

REFERENCE TO PARENT APPLICATION

This application is a division of U.S. application Ser. No. 09/087,408, filed May 29, 1998 now U.S. Pat. No. 6,285, 431, the disclosure of which is hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

(a) Field of the Invention

The present invention relates to a liquid crystal display having wide viewing angle.

(b) Description of the Related Art

A liquid crystal display (LCD) includes two substrates and a liquid crystal layer interposed therebetween. The transmittance of the light is controlled by the strength of the electric field applied to the liquid crystal layer.

A conventional twisted nematic (TN) liquid crystal display, which is one of the most widely used LCD, has a couple of transparent substrates which have transparent electrodes respectively on their inner surfaces, a liquid crystal layer between two substrates, and a couple of polarizers which are attached to the outer surfaces of the substrates respectively. In off state of the LCD, i.e, in the state that the electric field is not applied to the electrodes, the long axes of the liquid crystal molecules are parallel to the substrates and twisted spirally with a constant pitch from the inner surface of one substrate to that of the, other substrate, and thus the orientation of the long axes of the liquid crystal molecules vary continuously.

However, the contrast ratio of the conventional TN LCD in a normally black mode may not be so high because the incident light is not fully blocked in its off state, i.e., in absence of the electric field.

To solve this problem, a vertically aligned twisted nematic (VATN) mode LCD is proposed in the U.S. patent application Ser. No. 3,914,022 and in "Eurodisplay '93", pp. 158–159 by Takahashi.

The VATN in normally black mode may have an off state which Is sufficiently dark, because the liquid crystal molecules are aligned perpendicular to the substrates in off state. However, the viewing angle of the VATN LCD may not be so wide.

On the other hand, T. Yamamoto et al. disclosed a VATN simple matrix LCD using fringe fields in "SID '91, pp. 762–765", and Lien proposed a structure having an aperture in the pixel electrode to solve the problem of low transmittance in on state of a simple matrix multi domain VATN.

However, the structure that Lien proposed may have light leakage generated near the aperture.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to widen the viewing angle of LCD.

It is another object of the present invention to prevent the disclination of LCD.

These and other objects features and advantages are provided, according to the present invention, by a liquid crystal display comprising a first substrate having a common electrode, a second substrate having a pixel electrode and a storage capacitor electrode. One of the electrodes has an aperture and the storage capacitor electrode is located at the position corresponding to the aperture.

The storage capacitor electrode prevents the light leakage due to a fringe field generated from the aperture.

Between the first and the second substrates, a liquid crystal layer having negative dielectric anisotropy may be interposed. The liquid crystal layer may include chiral nematic liquid crystal or nematic liquid crystal having chiral dopant of 0.01–3.0 wt %.

Two substrates may have alignment layers respectively, to align the molecular axes of the liquid crystal molecules perpendicular to the substrates. The alignment layers may be rubbed or not.

The storage capacitor electrode may be connected to a gate line and the number of the storage capacitor electrode may be more than one.

It is preferable that the width of the aperture is 3–15 μm and the distance between the apertures is 8–50 μm.

To obtain the wide viewing angle, the linear apertures in adjacent pixel regions extend in the different directions. For example, if the direction of the aperture of one pixel is parallel to the gate line, the aperture of the adjacent pixel is preferably perpendicular to the gate line. As a result, the liquid crystal molecules rotate in 4 directions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A and **1**B are schematic diagrams of the alignment of liquid crystal molecules of a VATN LCD respectively in black state and white state according to an embodiment of the present invention

FIG. **2** shows the structure of the electrodes and the alignment of the liquid crystal molecules of a VATN LCD according to an embodiment of the present invention.

FIG. **3** is a layout view of a common substrate according to the first embodiment of the present invention

FIG. **4** is a layout view of a TFT (thin film transistor) substrate according to the first embodiment of the present invention.

FIG. **5** is a sectional view of a TFT substrate shown in FIG. **4** taken along the line V—V'.

FIG. **6** is a layout view of a common substrate according to the second embodiment of the present invention,

FIG, **7** is a layout view of a TFT substrate according to the second embodiment of the present invention.

FIG. **8** is a layout view of a common substrate according to the third embodiment of the present invention.

FIG, **9** is a layout view of a TFT substrate according to the third embodiment of the present invention.

FIG. **10** is a layout view of a common substrate according to the fourth embodiment of the present invention.

FIG. **11** is a layout view of a TFT substrate according to the fourth embodiment of the present invention.

FIG. **12** is a layout view of a substrate according to an embodiment of the present invention.

FIGS. **13**A and **13**B show rotated directions of the liquid crystal molecules near the apertures.

FIG. **14** is a layout view of a common substrate according to the fifth embodiment of the present invention.

FIG. **15** is a layout view of a TFT substrate according to the fifth embodiment of the present invention.

FIGS. **16**–**19** are layout views of substrates according to the sixth to the ninth embodiments of the present invention.

FIG. **20** is a sectional view of LCD according to an, embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in

which preferred embodiments of the present invention are shown. This invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the thickness of layers and regions are exaggerated for clarity.

FIGS. **1**A and **1**B are schematic diagrams of the alignment of liquid crystal molecules of a VATN LCD respectively in black state and white state according to an embodiment of the present invention. FIG. **2** shows the structure of the electrodes and the alignment of the liquid crystal molecules of a VATN LCD according to an embodiment of the present invention.

As shown in FIGS. **1**A and **1**B, two glass substrates **1** and **2** are spaced apart from each other. On the inner surfaces of the substrates **1** and **2**. transparent electrodes **12** and **120** made of a transparent conductive material such as ITO (indium tin oxide) or the like are formed respectively, and alignment layers **14** and **140** are formed thereon respectively. Between the substrates **1** and **2**, a liquid crystal layer **100** including a chiral nematic liquid crystal having negative dielectric anisotropy or a nematic liquid crystal doped with chiral dopant of 0.01–0.3 wt % is disposed. On the outer surfaces of the substrates **1** and **2**, polarizers **13** and **130** are attached. The polarizers **13** and **130** polarize the rays incident on the liquid crystal layer **100** and the rays out of the liquid crystal layer **100** respectively The polarizing directions of the polarizers **13** and **130** are perpendicular to each other. The alignment layers **14** and **140** may be rubbed or not.

FIG. **1**A shows the off state that the electric field is not applied, where the long molecular axes of the liquid crystal molecules **3** in the liquid crystal layer **100** are aligned perpendicular to the surface of the substrates **1** and **2** by the aligning force of the alignment layers **14** and **140**.

The polarized light by the polarizer **13** attached to the lower substrate **1** passes through the liquid crystal layer **100** without changing its polarization. Then, the light is blocked by the analyzer **130** attached to the upper substrate **2** to make a black state.

FIG. **1**B shows the on state that the sufficient electric field is applied to the liquid crystal layer **100** by the electrode **4** and **5**, where the liquid crystal molecules **3** in the liquid crystal layer **100** are twisted spirally by 90° from the lower substrate **1** to the upper substrate **2**, and the director of the liquid crystal layer **100** varies continuously. However, near the inner surfaces of two substrates **1**, **2**, the aligning force of the alignment layers **14**, **140** is larger than the force due to the applied electric field, and the liquid crystal molecules stay vertically aligned.

The polarized light by the polarizer **13** passes through the liquid crystal layer **100** and its polarization is rotated by 90° according to the variation of the director of the liquid crystal layer **100**. Therefore, the light passes through the analyzer **130** to make a white state.

FIG. **2** shows the structure of the electrodes and the alignment of the liquid crystal molecules of a VATN LCD according to an embodiment of the present invention. An ITO electrode **4** formed on the upper substrate **2** has an aperture **6**. In absence of electric field, as shown in FIG. **1**A, the liquid crystal molecules **3** stay in its vertically aligned state to show the black state. If the electric field applied to the liquid crystal layer by the electrodes **4** and **5**, in most regions between the electrodes **4** and **5**, the field direction is perpendicular to the substrates **1** and **2**. However, near the aperture of the ITO electrode **4**, the electric field is not completely perpendicular to the substrate **2**. The electric field near the aperture is called the fringe field. The long axes of the liquid crystal molecules tend to be perpendicular to the field direction since the liquid crystal layer have negative dielectric anisotropy. Therefore, the directions of the long axes of the liquid crystal molecules are tilted and twisted near the fringe field.

An LCD according to embodiments of the present invention includes a TFT (thin film transistor) substrate and a common substrate. On the TFT substrate, a plurality of gate lines and data lines crossing each other are formed, and the gate lines and the data lines define pixel regions. On the common substrate, a common electrode having apertures and a black matrix which defines pixel regions are formed.

According to the first to the fourth embodiments of the present invention, a storage capacitor electrode is formed at the position corresponding to the aperture to shield the light leakage.

Now, the first embodiment of the present invention will be described with reference to FIGS. **3**–**5**.

FIG. **3** is a layout view of a common substrate of a liquid crystal display according to the first embodiment of the present invention. FIG. **3** shows a pixel region, where a common electrode has apertures.

As shown in FIG. **3**, a black matrix pattern **7** is formed along the boundary of a pixel region P, and a common electrode **6** is formed to cover the entire surface of the common substrate. The common electrode **6** has two longitudinally long linear apertures **15** which are spaced apart from and parallel to each other in a pixel region.

It is preferable that the width of the apertures **15** may be 3–15 μm, and the distance between the apertures **15** may be 8–50 μm. The width of 3–12 μm and the distance of 10–30 μm would be better.

FIG. **4** is a layout view of a TFT substrate according to the first embodiment of the present invention, and FIG. **5** is a sectional view of the TFT substrate taken along the line V—V' of FIG. **4**.

As shown in FIGS. **4** and **5**, a first and a second gate lines **81** and **82** spaced apart from each other are formed on a transparent glass substrate **20**, and extend in the horizontal or transverse direction. Two storage capacitor electrodes **11** which are separated from and parallel to each other connected to both the gate lines **81** and **82** are formed on the substrate **20**. The storage capacitor electrodes **11** are longitudinally lay, and they are located at the positions corresponding to the apertures **15** in the common electrode **6** on the common substrate.

A gate insulating layer **30** covers the storage capacitor electrodes **11** and the first and the second gate lines **81** and **82**. A data line **9** perpendicular to the gate lines **81** and **82** is formed on the gate insulating layer **30**. A TFT having a gate electrode which is a portion of the first gate line **81** is formed at a portion near the intersection of the first gate line **81** and the data line **9**. A planarized passivation layer **40** is formed thereon, and a pixel electrode **10** overlapping the first and the second gate lines **51** and **82** and the data line **9** is formed on the passivation layer **40**. An alignment layer **50** is formed thereon, and the alignment layer **50** may be rubbed or may not.

Although the linear apertures in the common electrode extend longitudinally in this embodiment, they may extend horizontally or obliquely.

FIGS. **6** and **7** are the respective layout views of the common and TFT substrates having horizontal apertures according to the second embodiment.

As shown in FIG. **6**, a black matrix pattern **7** is formed along the boundary of a pixel region P, and a common electrode **6** is formed to cover the entire surface of the common substrate. The common electrode **6** has a plurality of horizontally long linear apertures **15** which are spaced apart from and parallel to each other in a pixel region.

The with and the distance of the apertures **15** may be the same as those of the first embodiment.

On the other hand, as shown in FIG. **7**, a first and a second gate lines **81** and **82** which are separated from each other and extend horizontally and a branch **12** connecting the gate lines **81** and **82** extending in a vertical direction are formed on a transparent glass substrate **20**. A plurality of storage capacitor electrodes **11** which are parallel to each other and to the gate lines **81** and **82** are formed on the substrate and connected to the branch **12**. The storage capacitor electrodes **11** are transversely lay, and they are located at the positions corresponding to the apertures **15** in the common electrode **6** on the common substrate.

FIGS. **8–11** are layout views of common and TFT substrates having oblique apertures according to the third and the fourth embodiments. In the third and the fourth embodiment, the apertures make an angle of 0°–90° to the data line and the gate line.

As shown in FIGS. **8** and **10**, a black matrix pattern **7** is formed along the boundary of a pixel region P, and a common electrode **6** is formed to cover the entire surface of the common substrate. The common electrode **6** has two obliquely long linear apertures **15** which are spaced apart from each other in a pixel region.

In the third embodiment shown in FIG. **8**, each pixel has an aperture extending in the down left direction from the up right edge and an aperture extending in the up left direction from the bottom right edge, and the end of apertures **15** reach the left central edge of the pixel On the other hand, in the fourth embodiment illustrated in FIG. **10**, each pixel has two parallel apertures extending in the up right or the down left direction.

The width and the distance of the apertures **15** may be the same as those of the first embodiment.

FIGS. **9** and **11** are the layout views of TFT substrates according to the third and the fourth embodiments of the present invention.

As shown in FIG. **9**, a first and a second gate lines **81** and **82** which are separated from each other and extend horizontally and a branch **12** connecting the gate lines **81** and **82** extending in a vertical direction are formed on a transparent glass substrate **20**. Two storage capacitor electrodes **11** on the substrate extend obliquely from the gate lines **81** and **82** to the left center of the pixel region P, and are connected to the branch **12**.

A TFT substrate illustrated in FIG. **11** has a first and a second gate lines **81** and **82**, a branch **12** and a data line **9** having the same shapes as those in the third embodiment shown in FIG. **9**. Two storage capacitor electrodes **11** parallel to each other extend obliquely in the up right or the bottom left direction and are connected to the branch **12**.

In the third and the fourth embodiments, as in the first embodiment, the position of the storage capacitor electrodes **11** are corresponding to the apertures **15** in the common electrode **6** on the common substrate to shield the light leakage due to a fringe field.

In the third and the fourth embodiments of the present invention, the alignment layers formed on the pixel electrode may be rubbed or may not. When the alignment layers are rubbed, the rubbing direction may make an angle of 0°–135° with respect to the direction of the linear aperture.

Next, the fifth embodiment of the present invention will be described. In the fifth embodiment, adjacent pixels have apertures extending different directions to widen the viewing angle.

FIG. **12** is a layout view of a common substrate according to the fifth embodiment.

As shown in FIG. **12**, a black matrix pattern **7** is formed and defines a plurality of pixel regions corresponding to the red, green and blue color filters R, G and B. An ITO electrode **4** having a plurality of linear apertures **15** is formed thereon. The extending directions of the linear apertures of adjacent pixel regions are different from each other, i.e., horizontal apertures and vertical apertures are arranged alternately by pixel. For example, a red pixel region has vertical apertures and an green pixel region adjacent to the red pixel region has horizontal apertures.

It is assumed to display red color using this LCD. Then, the blue and the green pixels remain in their OFF state, and only the red pixels turn on. If the extending direction of the apertures of a first red pixel is horizontal, and the extending direction of the aperture of a second red pixel adjacent to the first red pixel is vertical.

Now the behaviors of the liquid crystal molecules are described with reference to FIGS. **13**A and **13**B in this case.

The linear apertures **15** of the ITO electrode **4** extends vertically in FIG. **13**A, while the linear apertures **15** of the ITO electrode **4** extends horizontally in FIG. **13**B.

Here, the liquid crystal molecules are left-handed when viewed from the bottom of the drawing sheet.

When the voltage is applied to the electrodes **4** and **5**, the liquid crystal molecules tilt in the directions perpendicular to the direction of the electric field due to the voltage difference between the electrodes **4** and **5**, as shown in FIG. **2**. In addition, as shown in FIGS. **13**A and **13**B, the liquid crystal molecules rotate clockwise in xy plane.

The tilt directions of the liquid crystal molecules vary according to the extending directions of the apertures. Since the tilt directions of the molecules opposite each other with respect to an aperture are opposite, and there are two extending directions of the apertures, the number of the tilt direction is about four. on the Y axis in upper part twist to the right to the X axis, and those on the Y axis in lower part twist to the left to X axis due to the linear aperture formed along the Y axis.

Since the liquid crystal molecules tilt and rotate in four different directions, the viewing angles of up, down, left and right directions are equal and the gray inversion does not occur.

Now, the structures of the color filter and the TFT substrate according to the fifth embodiment are described more fully.

FIG. **14** is a layout view of a common substrate showing two adjacent pixels.

As shown in FIG. **14**, a black matrix pattern **7** which defines pixel regions **P1**, **P2** is formed on the substrate, and a common electrode **6** formed thereon.

The common electrode **6** has two vertical linear apertures **15** parallel to each other in the first pixel region **P1**, and has a plurality of horizontal linear apertures **15** parallel to each other in the second pixel region **P2** adjacent to the first pixel region **P1**.

The width and the distance of the apertures may be the same as those of the first embodiment.

FIG. **15** is a layout view of a TFT substrate according to the fifth embodiment of the present invention. In a pixel region **P1** corresponding to the pixel region **P1** on the common substrate in FIG. **14**, a first and a second gate lines **81** and **82** and two vertical storage capacitor electrodes **11** parallel to each other and connecting the gate lines **81** and **82** are formed as those in FIG. **4**. In a pixel region **P2**, a branch **12** connecting two gate lines **81** and **82** extends parallel to a data line **9**, and a plurality of storage capacitor electrodes **111** extend parallel to the gate lines **81** and **82** from the branch **12**.

As all the above-described embodiments, the storage capacitor electrodes **11** are located at the positions corresponding to the apertures **15** in the common electrode **6**.

The storage capacitor electrodes **11** overlaps a pixel electrode **10** to form storage capacitors, and play a role of a black matrix to prevent the light leakage caused by the disclination due to the apertures **15** in common electrode **6**.

The apertures in adjacent pixel regions may have various shapes. FIGS. **16–19** are layout views of the sixth to the ninth embodiments having variously shaped apertures in adjacent pixel regions

An LCD according to the sixth embodiment shown in FIG. **16** has first pixels having apertures shown in FIG. **10** and second pixels having apertures of shapes which is the same as the apertures in the first pixels rotated by 180° with respect to the central point of the pixel. In horizontal direction, two kinds of pixels are arranged alternately, and in vertical direction, pixels in a column are the same kind. As a whole, the apertures form a chevron shape in the sixth embodiment. An LCD according to the seventh embodiment shown in FIG. **17** has the same arrangement in the horizontal direction, however, in the vertical direction, two kinds of pixels are arranged alternately as in the horizontal direction. In the seventh embodiment, the apertures form a chevron shape in a row, but when viewing adjacent rows, the apertures form X or diamond shapes.

An LCD according to the eighth embodiment shown in FIG. **18** has first pixels having apertures shown in FIG. **8** and the second pixels having apertures of shapes which is the same as the apertures in the first pixels rotated by 180° with respect to the central point of the pixel. In horizontal direction, two kinds of pixels are arranged alternately, and in vertical direction, pixels in a column are the same kind. As a whole, the apertures form an X or diamond shape. An LCD according to the ninth embodiment shown in FIG. **19** has the same arrangement in the horizontal direction, however, in the vertical direction, two kinds of pixels are arranged alternately as in the horizontal direction. In the ninth embodiment, the apertures form an X or diamond shape in a row.

According to the embodiments of the present invention, column shaped spacers made of metal or organic material may be used instead of ball shaped spacers since the ball shaped spacers may cause light leakage due to the disturbance of the liquid crystal molecules near the spacers.

FIG. **20** shows a sectional view of an LCD having spacers according to an embodiment of the present invention. A liquid crystal layer **40** is interposed between a substrate **10** having a TFT **30** and a substrate **20** having a color filter (not shown). The TFT **30** formed on the lower substrate **10** includes a gate electrode **31**, a gate insulating layer **32** formed thereon, a semiconductor layer **33** formed on a portion of the gate insulating layer **32** over the gate electrode

31, source/drain electrodes **341**, **342** formed on the semiconductor layer **33**. A passivation layer **50** covers the entire surface of the substrate **10** having the TFT **30**. A pixel electrode **60** is formed in the pixel region and electrically connected to the drain electrode **342** through a contact hole in the passivation layer **50**. A spacer **100** made of a metal or an organic material is formed on the TFT.

In the embodiments of the present invention, the apertures are formed in the common electrode **6**, however, the apertures can be formed in the pixel electrode **10**. When the apertures are formed in the pixel electrode **10**, the fringe field generated between the pixel electrode **10** and the common electrode **6** may be affected by the voltages applied to the data line **9**, the gate lines **81** and **82** and the storage capacitor electrode **11**. To remove the influence due to the voltage applied to those signal lines, it is preferable that the thickness of the passivation layer **50** is equal to or more than 3 μm by using organic insulating material.

In the embodiments of the present invention, although the storage capacitor electrodes **11** are connected to the gate lines **81** and **82**, the storage capacitor electrodes **11** may be connected to another signal sources.

According to the embodiments of the present invention, the liquid crystal molecules are tilted in the various directions due to the fringe field to have a wide viewing angle, and the storage capacitor electrodes prevents the light leakage near the fringe field.

In the drawings and specification, there have been disclosed typical preferred embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

What is claimed is:

1. A liquid crystal display comprising:

a first substrate;

a second substrate, spaced apart from the first substrate;

first and second adjacent pixel regions on one of the first substrate or the second substrate; and

first and second field-generating electrodes on the first and second adjacent pixel regions, respectively, the first field-generating electrode having a first aperture and a second aperture and the second field-generating electrode having a third aperture and a fourth aperture, an orientation of at least one of the first and second apertures of the first field-generating electrode being different from an orientation of at least one of the third and fourth apertures of the second field-generating electrode;

wherein the one of the first and second substrates comprising the first and second pixel regions comprises a plurality of data lines and a plurality of gate lines that define the first and second pixel regions, wherein orientations of the first and second apertures in the first field-generating electrode are parallel to the plurality of gate lines and wherein orientations of the third and fourth apertures of the second field-generating electrode are perpendicular to the plurality of gate lines.

2. A liquid crystal display comprising:

a first substrate;

a second substrate, spaced apart from the first substrate;

first and second adjacent pixel regions on one of the first substrate or the second substrate; and

first and second field-generating electrodes on the first and second adjacent pixel regions, respectively, the first field-generating electrode having a first aperture and a second aperture and the second field-generating electrode having a third aperture and a fourth aperture, an orientation of at least one of the first and second apertures of the first field-generating electrode being different from an orientation of at least one of the third and fourth apertures of the second field-generating electrode;

wherein the first and second apertures extend downward at angle from a left side of the first field-generating electrode and wherein the third and fourth apertures extend downward at angle from a right side of the second field-generating electrode.

3. A liquid crystal display according to claim **2** wherein the angle between the left side of the first field-generating electrode and an under side of the first aperture and an under side of the second aperture is from about 30 to about 50 degrees and wherein the angle between the right side of the second field-generating electrode and an under side of the third aperture and an under side of the fourth aperture is from about 30 to about 50 degrees.

4. A liquid crystal display comprising:

a first substrate;

a second substrate, spaced apart from the first substrate;

first and second adjacent pixel regions on one of the first substrate or the second substrate; and

first and second field-generating electrodes on the first and second adjacent pixel regions, respectively, the first field-generating electrode having a first aperture and a second aperture and the second field-generating electrode having a third aperture and a fourth aperture, an orientation of at least one of the first and second apertures of the first field-generating electrode being different from an orientation of at least one of the third and fourth apertures of the second field-generating electrode;

wherein the first and third apertures extend downward at angle from a left side of the first field-generating electrode and wherein the second and fourth apertures extend downward at angle from a right side of the second field-generating electrode.

5. A liquid crystal display according to claim **4** wherein the angle between the left side of the first field-generating electrode and an under side of the first aperture and an under side of the third aperture is from about 120 to about 150 degrees and wherein the angle between the right side of the second field-generating electrode and an under side of the second aperture and an under side of the fourth aperture is from about 120 to about 150 degrees.

6. A liquid crystal display comprising:

a first substrate;

a second substrate, spaced apart from the first substrate;

first and second adjacent pixel regions on one of the first substrate or the second substrate; and

first and second field-generating electrodes on the first and second adjacent pixel regions, respectively, the first field-generating electrode having a first aperture and a second aperture and the second field-generating electrode having a third aperture and a fourth aperture, an orientation of at least one of the first and second apertures of the first field-generating electrode being different from an orientation of at least one of the third and fourth apertures of the second field-generating electrode;

wherein a distance between the first aperture and the second aperture is from about 8 μm to about 50 μm and wherein a distance between the third aperture and the fourth aperture is from about 8 μm to about 50 μm.

7. A liquid crystal display comprising:

a first substrate;

a second substrate, spaced apart from the first substrate;

a pixel region on one of the first substrate and the second substrate; and

a field-generating electrode on the pixel region, the field-generating electrode having a first aperture having a first orientation and a second aperture having a second orientation different from the first orientation of the first aperture; wherein the first aperture extends upward at angle from a left side of the field-generating electrode and wherein the second aperture extends downward at angle from the left side of the field-generating electrode and wherein the angle between the left side of the field-generating electrode and an under side of the first aperture is from about 120 to about 150 degrees and wherein the angle between the left side of the field-generating electrode and an under side of the second aperture is from about 30 to about 50 degrees.

8. A liquid crystal display comprising:

a first substrate;

a second substrate, spaced apart from the first substrate;

a pixel region on one of the first substrate and the second substrate; and

a field-generating electrode on the pixel region, the field-generating electrode having a first aperture having a first orientation and a second aperture having a second orientation different from the first orientation of the first aperture, wherein a distance between the first aperture and the second aperture is from about 8 μm to about 50 μm.

* * * * *

Exhibit 1

US007295196B2

(12) **United States Patent**
Kim et al.

(10) **Patent No.: US 7,295,196 B2**
(45) **Date of Patent: Nov. 13, 2007**

(54) **LIQUID CRYSTAL DISPLAY PANEL WITH SIGNAL TRANSMISSION PATTERNS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **11/109,680**

(22) Filed: **Apr. 20, 2005**

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(63) Continuation of application No. 10/693,459, filed on Oct. 27, 2003, which is a continuation of application No. 09/551,404, filed on Apr. 17, 2000, now Pat. No. 6,639,589.

(30) **Foreign Application Priority Data**

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G09G 3/36 (2006.01)

(52) **U.S. Cl.** **345/206**; 345/87; 345/903; 345/905; 349/139; 349/149; 349/151; 349/152

(58) **Field of Classification Search** 345/87, 345/206, 903, 905; 349/139, 143, 149, 150, 349/151, 152

See application file for complete search history.

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Primary Examiner—Bipin Shalwala
Assistant Examiner—Vincent E. Kovaick
(74) *Attorney, Agent, or Firm*—Don C. Lawrence; MacPherson Kwok Chen & Heid LLP

(57) **ABSTRACT**

A liquid crystal display of compact size is disclosed. The liquid crystal display has a tape carrier package and a single integrated PCB for processing a gate driving signal and data driving signal. The tape carrier package includes a base substrate, a gate driver IC formed on said base substrate, an input pattern formed on said base substrate that applies gate driving signals input from an external device to the gate driver IC, a first output pattern formed on said base substrate that outputs a first gate driving signal processed in said gate driver IC, and a second output pattern formed on said base substrate, that outputs a second gate driving signal bypassing the gate driver IC among the gate driving signals.

19 Claims, 7 Drawing Sheets

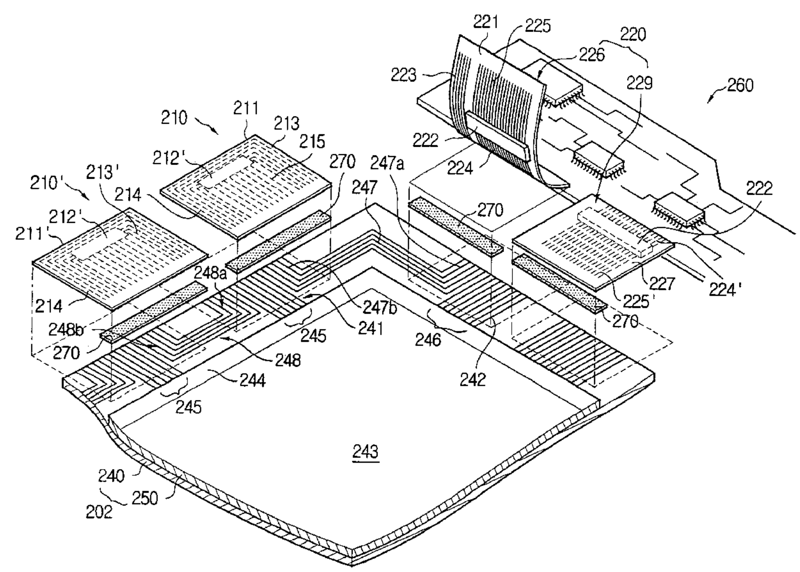

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FIG. 1

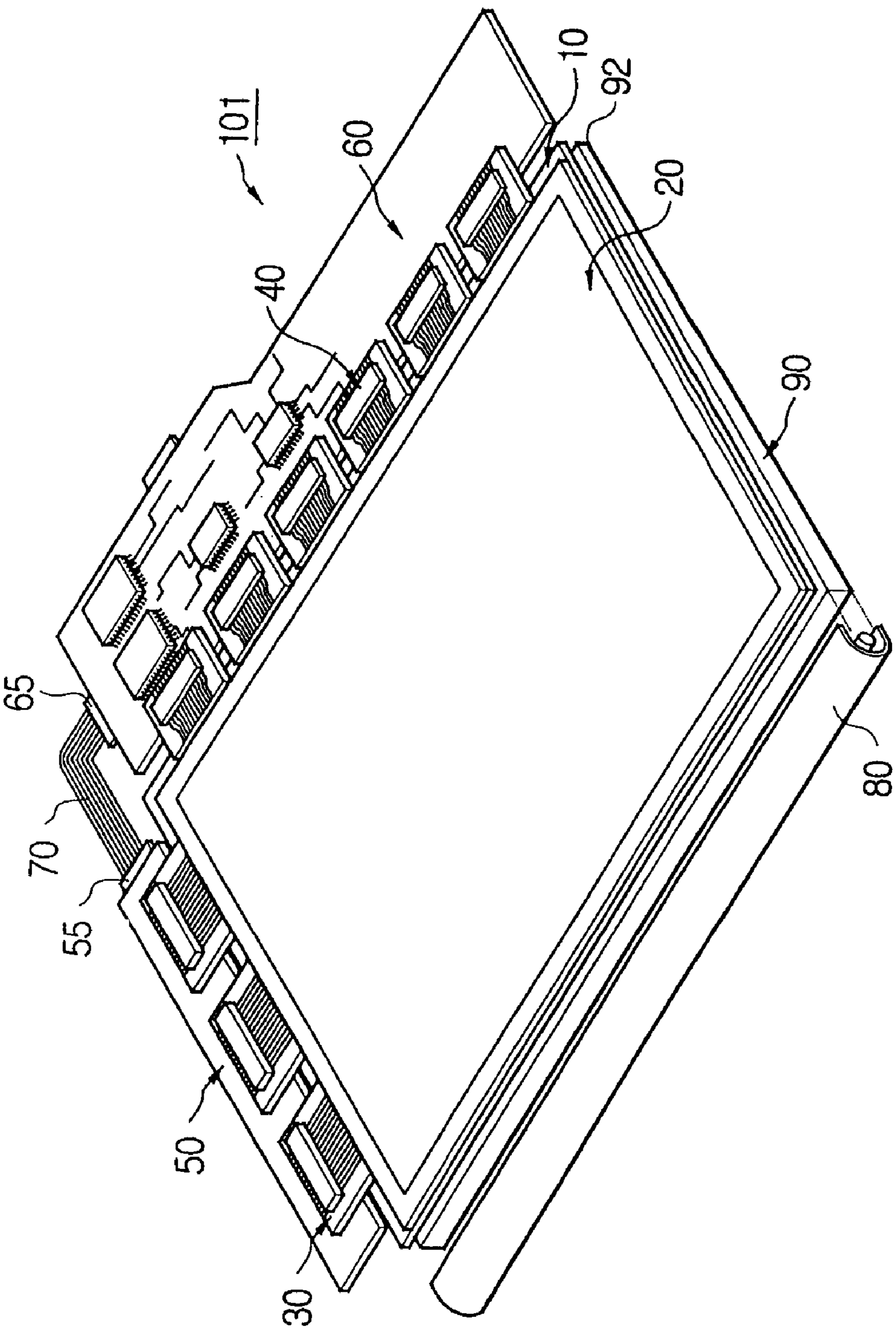

FIG. 2

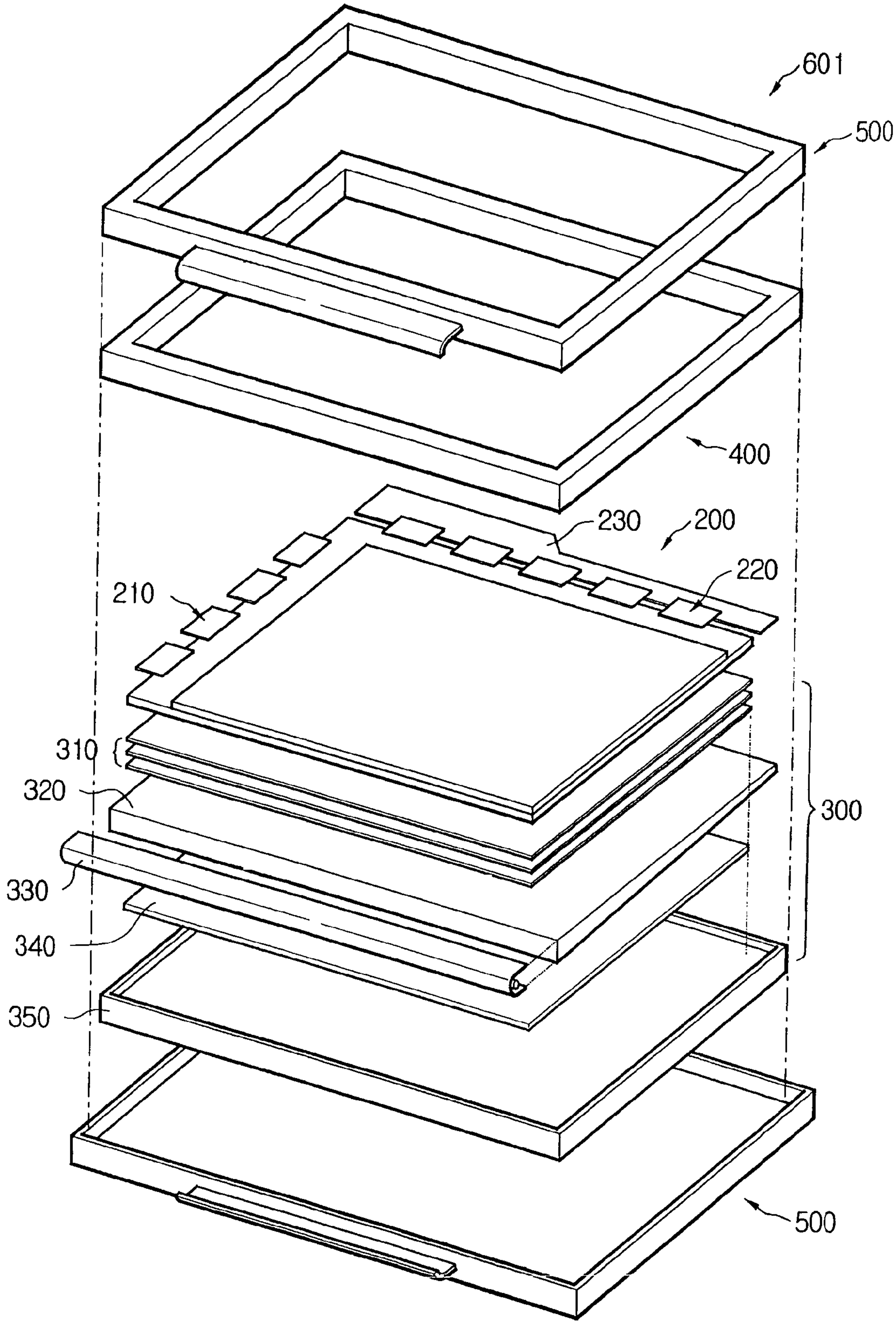

FIG. 3

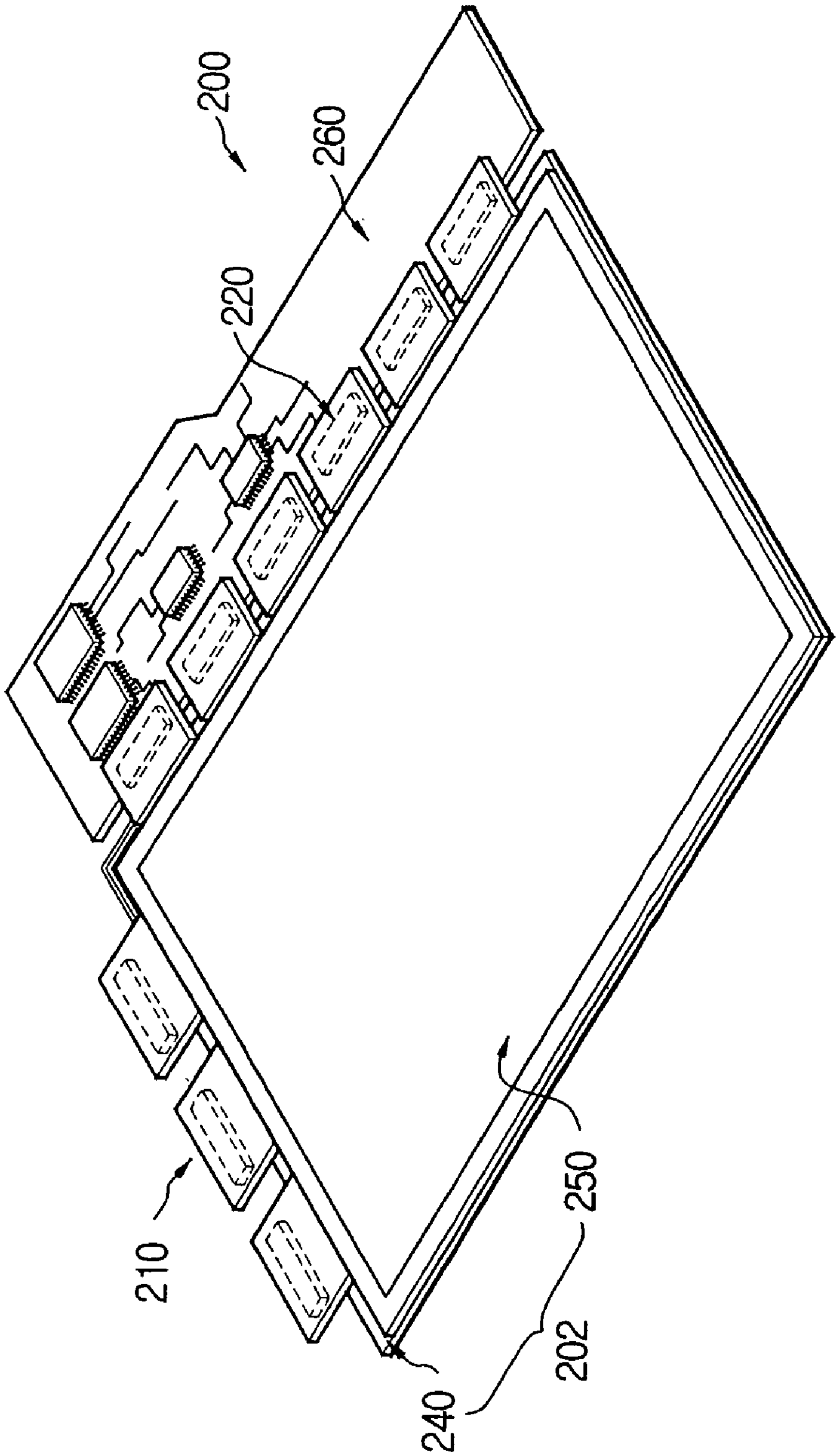

FIG. 4

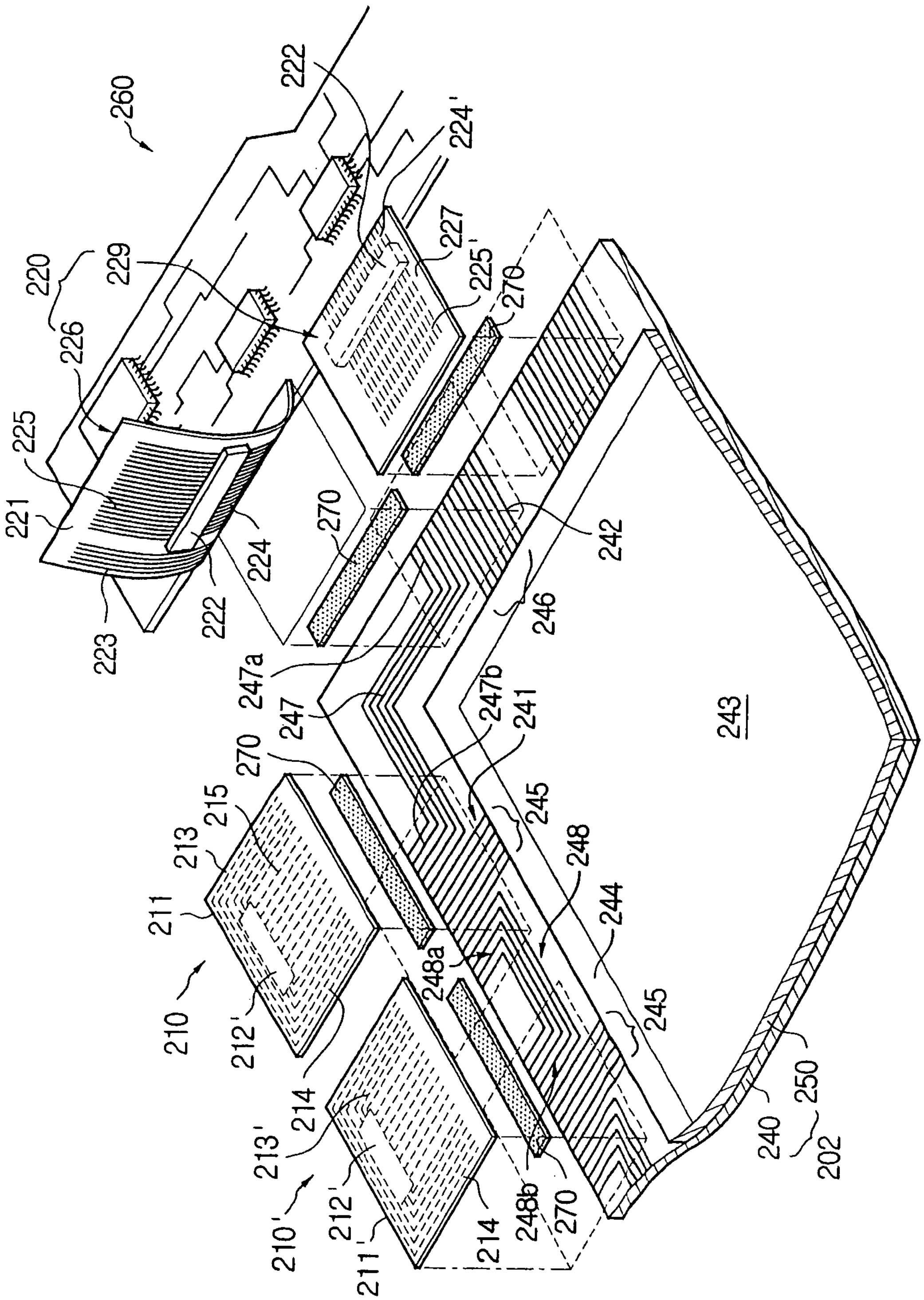
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FIG. 5

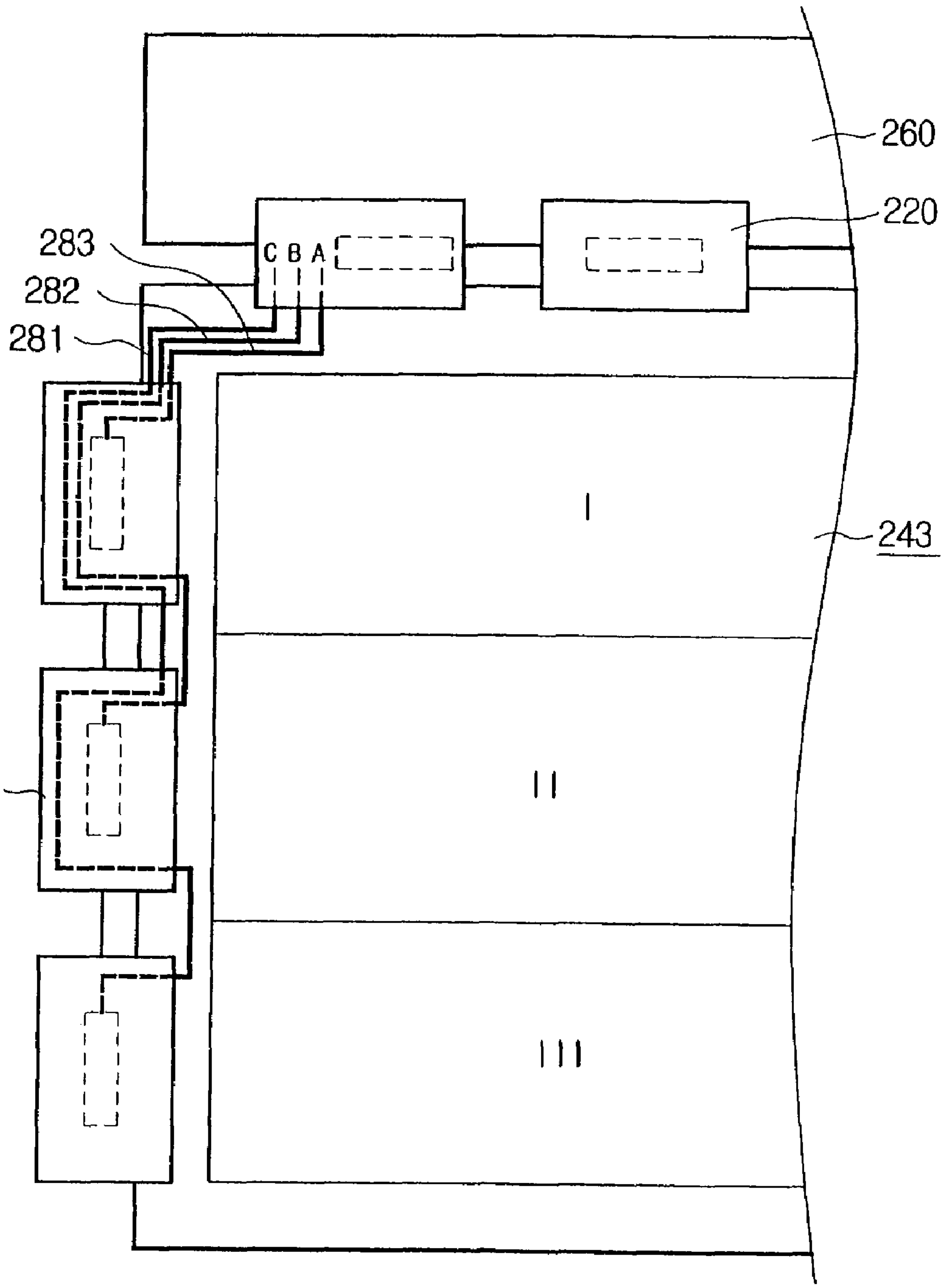


FIG. 6

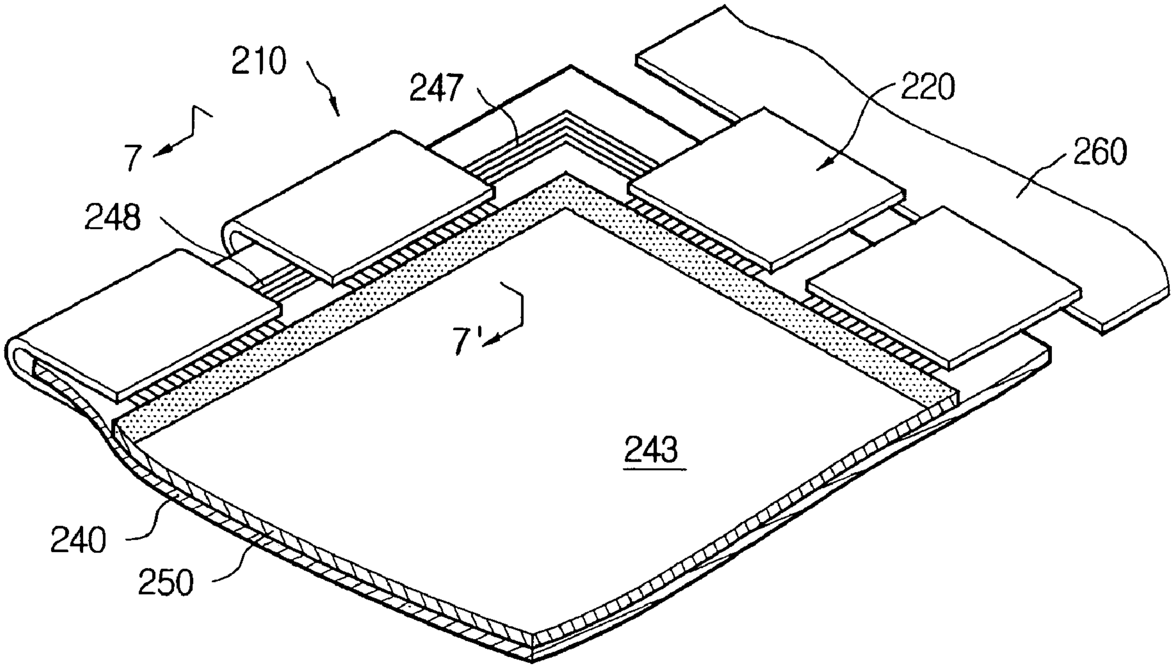


FIG. 7

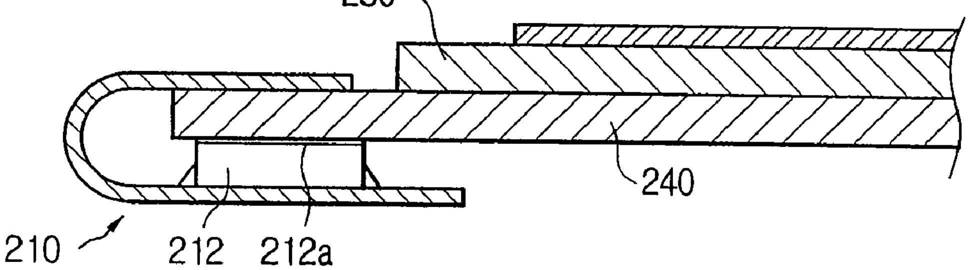
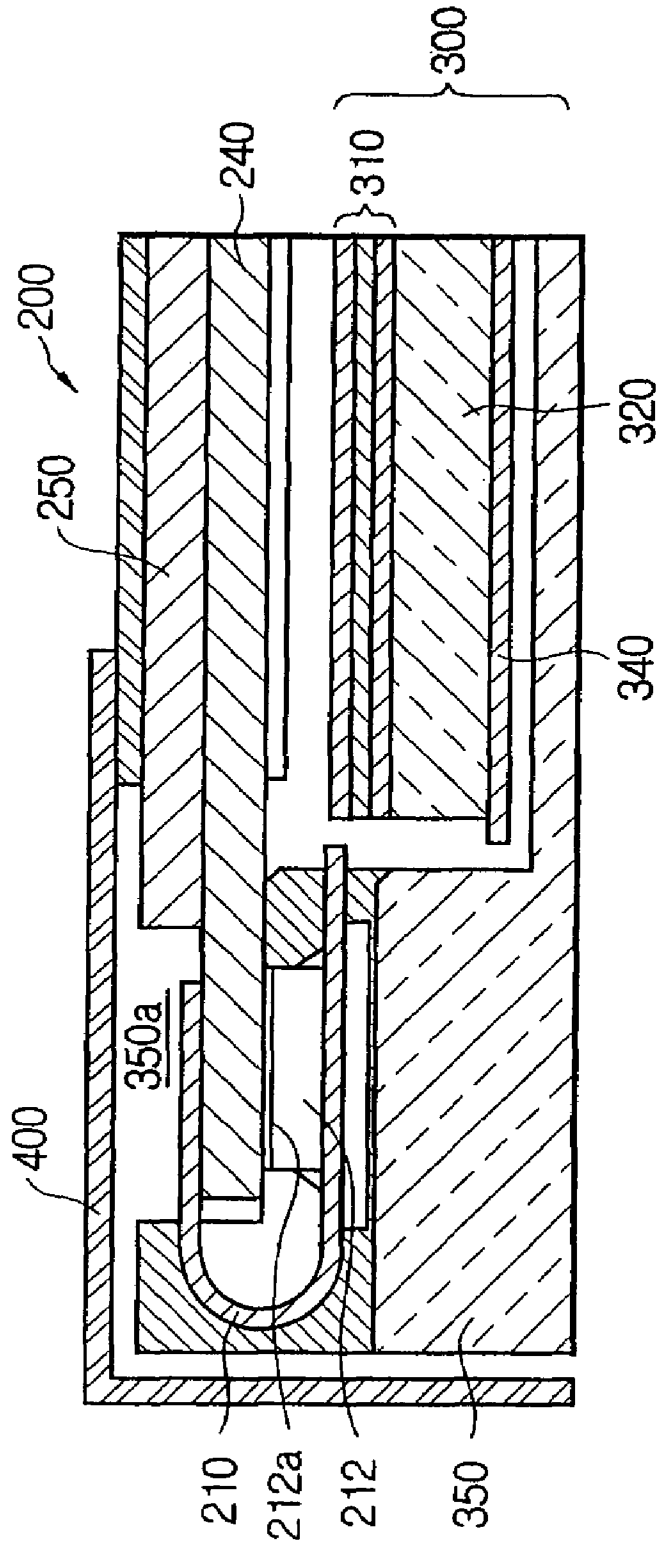


FIG. 8



LIQUID CRYSTAL DISPLAY PANEL WITH SIGNAL TRANSMISSION PATTERNS

CROSS REFERENCE

This application is a continuation application of Applicant's U.S. patent application Ser. No. 10/693,459, filed on Oct. 27, 2003, which is a continuation application of U.S. patent application Ser. No. 09/551,404 filed on Apr. 17, 2000, which issued as U.S. Pat. No. 6,639,589 on Oct. 28, 2003, which claims priority to and the benefit of Korean Patent Application No. 1999-13650, filed on Apr. 16, 1999, which are all hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a tape carrier package for a compact size liquid crystal display (LCD), and more particularly to a tape carrier package (TCP) capable of receiving both of gate signal and data signal which are processed in a single integrated printed circuit board and transmitting the processed signals to an LCD panel and another TCP. Further, the invention relates to a liquid crystal display panel to which the tape carrier package is applied.

2. Description of the Related Art

Generally, an LCD is a mostly used type of flat panel display. Especially, the small size, lighter weight and lower power consumption render the LCD to replace the traditional cathode ray tube (CRT). The LCD is currently used as a monitor for a lap-top computer and even for a desktop computer, gaining its popularity.

As shown in FIG. **1**, an LCD includes an LCD panel **101** and a light supply unit. The LCD panel **101** includes a TFT substrate **10**, a color filter substrate **20**, multiple gate TCPs **30** connected to gate lines (not shown) of the TFT substrate **10**, multiple data TCPs **40** connected to data lines (not shown) of the TFT substrate **10**, a gate PCB **50** connected to the multiple gate TCPs **30**, a data PCB **60** connected with the multiple data TCPs **40**. The light supply unit includes multiple optical sheets such as a light guiding plate **90**, a light diffusing plate (not shown), etc., a lamp assembly **80**, and a receiving case called as "mold frame". The light guiding plate **90** has a decreasing thickness as it travels from the lamp unit **80** to the data PCB **60**.

A power supply unit and a controller that processes gate signals and data signals coming from an external device are mounted on the data PCB **60**. A gate voltage supply part is formed on the gate PCB **50** and supplies a gate driving voltage to gate lines by a control signal from the controller on the data PCB **60**.

To supply the control signal and the gate driving voltage into the gate PCB **50** from the data PCB **60**, connectors **55** and **65** are respectively installed in the gate PCB **50** and data PCB **60** and are connected to each other through a connecting member, "flexible printed circuit (FPC)".

Semiconductor fabrication technologies have developed in the areas of thin film formation, and packaging. This allows semiconductor devices to be mounted on the gate PCB **50** and to function as gate power supply source on the data PCB **60**.

Under such a configuration, the gate PCB **50** only transfers to the gate TCP **30** gate driving signals processed in the data PCB **60**.

The conventional LCD has following problems.

First, in order to apply gate driving signals processed in data PCB **60** to gate PCB **50**, gate PCB **50** and data PCB **60** need connectors **55** and **65**.

The connectors **55** and **56** are generally installed on the front surface or on the rear surface of the PCBs **50** and **60**. This increases the thickness of the LCD and makes it difficult to achieve a compact size LCD.

And the flexible printed circuit (FPC) **70** that connects the connector **55** and the connector **65** complicates the assembly process and increases the fabrication costs.

Finally, a bent type PCB that is mostly used currently bends a gate PCB **50** and data PCB **60** and they are fixed at the rear surface of the reflecting plate of a backlight assembly. In such a configuration, the data PCB **60** is put in a space between a relatively thin side edge **92** of the non-symmetric light guiding plate **90** and the mold frame. Thus the data PCB **69** does not increase the thickness of the LCD much. On the other hand, the gate PCB **50** is put in a space between a thickness varying side of the light guiding plate **90**, and the mold frame. Specifically, one side of the gate PCB **50** is attached to a thick portion of the rear surface of the light guiding plate **90**, making a thick LCD depending on the thickness of the light guiding plate **90**.

SUMMARY OF THE INVENTION

The present invention is to provide an integrated PCB that has a gate PCB and a data PCB on one board and is capable of allowing driving signals to be applied to gate lines and data lines without using additional connectors and flexible printed circuits.

It is another object of the present invention to allow a tape carrier package that receives a driving signal from the integrated PCB to transmit the received driving signal into another tape carrier package.

It is yet another object of the present invention to prevent delays of driving signals when a driving signal processed in the integrated PCB is sent to gate lines or data lines via tape carrier packages.

It is still another object of the present invention to provide an improved assembly between tape carrier packages and TFT substrate, thereby attaining an easy carrying and decreasing the thickness of the panel.

To achieve these and other advantages in accordance with the purpose of the present invention as embodied and broadly described, a tape carrier package comprises a base substrate, a gate driver IC formed on the base substrate, an input pattern formed on the base substrate that supplies gate driving signals input from an external device to the gate driver IC, a first output pattern formed on said base substrate that outputs a first gate driving signal processed in the gate driver IC, and a second output pattern formed on said base substrate, that outputs a second gate driving signal bypassing the gate driver IC among the gate driving signals.

Also a liquid crystal display panel assembly and a liquid crystal display using such an assembly are disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and other advantages of the present invention will become more apparent by describing in detail a preferred embodiment with reference to the attached drawings in which:

FIG. **1** is a perspective view showing a conventional liquid crystal display panel;

FIG. **2** is an exploded perspective view of the liquid crystal display according to a preferred embodiment of the present invention;

FIG. **3** is a perspective view of the liquid crystal panel according to a preferred embodiment of the present invention;

FIG. **4** is a partially exploded perspective view of the liquid crystal display panel according to a preferred embodiment of the present invention;

FIG. **5** is a schematic view for describing an operation of the liquid crystal display panel according to a preferred embodiment of the present invention;

FIG. **6** is a perspective view showing an assembly of tape carrier package and TFT substrate of the liquid crystal display panel according to a preferred embodiment of the present invention;

FIG. **7** is a sectional view taken along the line **7-7'** of FIG. **6**; and

FIG. **8** is a partial sectional view of the liquid crystal display according to a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

Hereinafter, a liquid crystal display panel, a tape carrier package and a liquid crystal display according to the present invention are described more fully with reference to the accompanying drawings.

FIG. **2** is an exploded perspective view of the liquid crystal display according to a preferred embodiment of the present invention.

The liquid crystal display **601** comprises a liquid crystal display panel assembly **200**, a back light assembly **300**, a chassis **400** and a cover **500**.

The back light assembly **300** is comprised of optical sheets **310**, a light guiding plate **320**, a lamp assembly **330**, a light reflecting plate **340** and a mold frame as a receiving container.

Hereinafter, the liquid crystal display panel assembly **200** according to the present invention is described referring to the FIG. **3** and the liquid crystal display panel is then described more fully referring to FIG. **4**.

Referring to FIG. **3**, the liquid crystal display panel assembly **200** comprises a liquid crystal display panel **202** having a TFT substrate **240** and a color filter substrate **250**, a liquid crystal (not shown) interposed between the TFT substrate **240** and the color filter substrate **250**, tape carrier packages **210** and **220** and a single integrated PCB **260**.

Referring to FIG. **4**, the liquid crystal display panel **202** comprises a TFT substrate **240** and a color filter substrate **250**. The filter substrate **250** is smaller than the TFT substrate **240** and faces the TFT substrate **240**. The TFT substrate **240** includes a gate **261**, a data line **242**, a thin film transistor (not shown) and a pixel electrode (not shown).

The tape carrier packages **210**, **210'**, **226**, and **229** are electrically coupled to the TFT substrate **240** and includes gate tape carrier packages **210** and **210'** and data tape carrier packages **226** and **229**. The gate tape carrier packages **210** and **210'** are connected to the gate lines on the TFT substrate **240**. The data tape carrier packages **226** and **229** are connected to the data lines.

The single integrated PCB **260** that is electrically connected to the tape carrier packages **226** and **229** has various driving elements for processing gate driving signals and data driving signals. The gate driving signals are input to the gate tape carrier package **210** and the data driving signals are input to the data tape carrier package **220**.

The color filter substrate **250** includes a transparent glass substrate **250**. The transparent glass substrate **250** has a lattice type black matrix (not shown), an RGB pixel (not shown) and a transparent and conductive ITO (Indium Thin Oxide) electrode. Here, the RGB pixels are formed by patterning a photoresist mixed with RBG pigment. The ITO electrode functions as a common electrode.

Meanwhile, the TFT substrate **240** includes a transparent glass substrate. On the transparent glass substrate, a plurality of thin film transistors (not shown) each including a gate, a source, and a drain are formed in a matrix arrangement by the semiconductor thin film formation process.

Gate terminals of all the thin film transistors in a row are connected to a gate line **241** that is extended to an end of the one side of the TFT substrate **240**. Source terminals of all the thin film transistors in one column are connected to a data line **242** formed at an end of the other side of the TFT substrate **240**. The drain terminal of each thin film transistor is connected to an ITO electrode, which is a pixel electrode. Therefore, the ITO electrode faces the common electrode of the color filter substrate **250**.

Further, the gate lines **241** are disposed in an effective display region **243** at the same interval with respect to each other while they are disposed in a perimeter region with a smaller interval than the interval of the gate line of the effective display region **243**, i.e., the gate lines **241** in the perimeter region are concentrated towards output terminals of the TCPs **210** and **210'**.

The preferred embodiment of the present invention has three gate line groups, although FIG. **4** shows only two gate line groups **245**.

Also, the data lines **242** are disposed in the effective display region **243** at the same interval with respect to each other. The data lines **242** are collected toward output terminals of the TCPs **226** and **229** on the perimeter region **244** and form a data line group **246** on the perimeter region **244** and connected to the data tape carrier packages **226** and **229**.

The preferred embodiment of the present invention has six data line groups and FIG. **6** shows only two data line groups **246**.

Some lines of a gate line group **245** placed at one edge and some lines of a data line group **246** placed at one edge around a corner of the TFT substrate **240** are connected to each other, thereby forming a first gate driving signal transmission line **247**.

One end of the first gate driving signal transmission line **247** extends to one side of the TFT substrate **240** in which the end of the outermost gate line group **245** is formed. The other end of the first gate driving signal transmission line **247** extends to one side of the TFT substrate **240** in which the end of the outermost data line group **246** adjacent to the gate line group **245** is disposed.

In the first gate driving signal transmission line **247**, an input terminal **247***a* that receives a signal is defined as one end portion of the first gate driving signal transmission line **247** at the side of the TCP **226**. And an output terminal **247***b* is defined as the other end of the first gate driving signal transmission line **247** at the side of the TCP **221**.

Meanwhile, a second gate driving signal transmission line **248** is formed at the space between the two gate line groups **245**.

One end of the second gate driving signal transmission line **248** is formed at one side of the TFT substrate **240** and

extends to a desired length in parallel with the gate line group **245**. The second gate driving signal transmission line **248** is bent perpendicularly to the adjacent gate line group **245** and extends again to a desired length. And the second gate driving signal transmission line **248** is then bent to be parallel with the adjacent gate line group **245** and extends to the other side of the TFT substrate **240**.

At this time, an input terminal **248***a* is defined as one end portion of the second gate driving signal transmission line **248** and an output terminal **248***b* is defined as the other end portion of the second gate driving signal transmission line **248**.

The gate tape carrier packages **210** and **210'** and data tape carrier packages **226** and **229** will be described more fully referring to the FIG. **4**.

The gate tape carrier package **210** is comprised of a FPC **211**, a gate driver IC **212**, a gate driving signal input pattern **213**, a first gate driving signal output pattern (or a bypass line) **214**, a second gate driving signal output pattern **215**.

The gate driver IC **212** is disposed at the rear surface of the FPC **211** in a flip chip type manner. The second gate driving signal output pattern **215** is disposed at the FPC **211** on which the gate driver IC **212** is disposed. One end of the second gate driving signal output pattern **215** is connected with output terminals of the gate driver IC **212** and the other end of the second gate driving signal output pattern **215** is connected through an anisotropic conductive film **270** to the gate line group **245**.

The gate driving signal input pattern **213** receives the gate driving signal from the output terminal **247***b* of the first gate driving signal transmission line **247** and sends the signal to the gate driver IC **212**.

Thus, one end of the gate driving signal input pattern **213** is connected through the anisotropic conductive film **270** to the output terminal **247***b* of the first gate driving signal transmission line **247** and the other end of the gate driving signal input pattern **213** is connected to the input terminals of the gate driver IC **212**.

The first gate driving signal output pattern **214** relays the gate driving signal from the TCP **226** to the input terminal **248***a* of the second gate driving signal transmission line **248** formed between the gate line groups **245**.

To realize this, one end of the first gate driving signal output pattern **214** is connected through the anisotropic conductive film **270** to the input terminal **248***a* of the second gate driving signal transmission line **248** and the other end the first gate driving signal output pattern **214** is connected to the output terminal **247***b* of the first gate driving signal transmission line **247**.

At this time, the first gate driving signal output pattern **214** and the gate driving signal input pattern **213** are formed to be symmetric with respect to the gate driver IC **212**.

If an output enable signal (OE signal) is ON, the gate driving signal, which is input through the gate driving signal input pattern **213** to the gate driver IC **212**, is processed in the corresponding gate driver IC **212**, and then applied to the second gate driving signal output pattern **215**. If the OE signal is OFF, the gate driving signal is not applied to the second gate driving signal output pattern **215** but to the first gate driving signal output pattern **214**.

Meanwhile, the data tape carrier package includes a plurality of packages, i.e., a dual functioning tape carrier package **226** for processing the gate driving signals and the data driving signals and a single functioning tape carrier package **229** only for the data driving signal.

Referring to FIG. **4**, the dual functioning tape carrier package **226** for gate/data driving signals comprises a FPC

221 that is a flexible base film **221**, the gate driving signal transmission pattern **223**, a data driver IC **222**, a data driving signal input pattern **224** and a data driving signal output pattern **225**.

Further, the data driver IC **222** is disposed at the rear surface of the FPC **221** in a flip chip type manner. One end of the data driving signal input pattern **224** is connected to input terminals of the data driver IC **222**. And the other end of the data driving signal input pattern **224** is connected to the single integrated PCB **260**.

In addition, one end of the data driving signal output pattern **225** is connected to output terminals of the data driver IC **222**, and the other end of the data driving signal output pattern **225** is connected through a anisotropic conductive film **270** to the aforementioned data line group **246**.

On the FPC **221** of the dual functioning tape carrier package **226** for the gate/data driving signals, there are formed the data driving signal output pattern **225**, the data driving signal input pattern **224**, the data driver IC **222** and the gate driving signal transmission pattern **223** that is separate from the data driver IC **222**.

One end of the gate driving signal transmission pattern **223** is connected to the single integrated PCB **260**. And the other end of the gate driving signal transmission pattern **223** is connected through the anisotropic conductive film **270** to the input terminal **247***a* of the first gate driving signal transmission line **247**.

Meanwhile, the single functioning tape carrier package **229** comprises a FPC **227**, a data driver IC **222**, a data driving signal input pattern **224'** and a data driving signal output pattern **225'**.

One end of the data driving signal input pattern **224'** is connected to the single integrated PCB **260**. And the other end of the data driving signal input pattern **224'** is connected to input terminals of the data driver IC **222**. One end of the data driving signal output pattern **225'** is connected to output terminals of data driver IC **222**. And the other end of the data driving signal output pattern **225'** is connected through the anisotropic conductive film **270** to the data line group **246**.

Therefore, the gate driving signal generated from the single integrated PCB **260** is input through the gate driving signal transmission pattern **223** of the dual functioning tape carrier package **226** for the gate/data driving signal, the input terminal **247***a* of the first gate driving signal transmission line **247**, the output terminal **247***b* of the first gate driving transmission line **247** and the gate driving signal input pattern **213** of the gate tape carrier package **210** to the gate driver IC **212**. The gate driving signal is then input through the second gate driving signal output pattern **215** to the gate line group **245** by the OE signal. Meanwhile, some of the gate driving signal generated from the single integrated PCB **260** are input through the first gate driving signal output pattern **214** to the gate driving signal input patter **213'** or the first gate driving signal output pattern **214'** of the adjacent TCP **211'**.

The signals that come from the single integrated PCB **260** through the above passages to the gate line group **245** are a gate clock, the OE signal, a V_{ON} signal which is a turn-on signal of the thin film transistor and a V_{OFF} signal which is a turn-off signal of the thin film transistor.

In addition, the data driving signal generated from the single integrated PCB **260** is input through the tape carrier package **221** for the gate/data driving signal and the single functioning tape carrier package **229** only for the data driving signal to the data line group **246** of the TFT substrate **240**.

The signals input from the single integrated PCB **260** through the data driving signal input patterns **224** and **224'**, the data driver IC **222** and the data driving signal output patterns **225** and **225'** to the data line group **246**, are a STH (Start Horizontal) signal for exactly latching a color data from an outer data processing unit to the data driver IC **222**, a LOAD signal which outputs the signal latched in the data driver IC **222** to the liquid crystal display panel assembly **200**, a clock signal for transmitting the data and RGB color data, etc.

Next, operations of the liquid crystal display according to the present invention are described with reference to the accompanying drawings.

Video signals as well as electric power, control signals, and color data are input from an external information processing unit to the single integrated PCB **260**. The single integrated PCB **260** then generates gate driving signals and data driving signals depending on the input video signals. Thereafter, the data driving signals generated from the single integrated PCB **260** are respectively input into the respective data driver IC **222** and **222'** via the data driving signal input patterns **224** and **224'** of data driving signal transmission lines of the dual functioning tape carrier package **226** and the single functioning tape carrier package **229**. The processed data driving signals are loaded to selected data lines **242** of the data line group **246** via the data driving signal output patterns **225** and **225'**. At this time, gray scale voltages for displaying colors are also applied to respective data lines **242**.

Simultaneously, among gate driving signals processed in the single integrated PCB **260**, a gate voltage is sent to an input terminal **247***a* of the first gate driving signal transmission line **247** through the gate driving signal transmission pattern. One component of the gate driving signals is a gate voltage. The gate voltage goes along the first gate driving signal transmission line **247** and then is sent to the input terminal of the gate driving signal input pattern **213**.

The driving signals inputted to the gate driving signal input pattern **213** are also transferred into the gate driving signal input pattern **213'** of the adjacent gate tape carrier package **210'** through the first gate driving signal output pattern **214** connected to the input terminal of the gate driving signal input pattern **213** and the input terminal **248***a* of the second gate driving signal transmission line **248** printed on the TFT substrate **240**. By such signal transmissions, all the gate driver IC **212** and **212'** are prepared to apply the gate driving signals to the gate lines by the OE signal.

Next, the OE signal is carried in or carried out into the gate driver ICs **212** and **212'** via the gate driving signal pattern **223** of the TCP **226**, the first gate driving signal transmission line **247**, the gate driving signal input pattern **213**, and the second gate driving signal transmission line **248** in the named order and thereby pre-designated gate voltages, such as turn-on voltage Von and turn-off voltage Voff are applied to all of the gate lines within a period of one frame.

As the Von signal is input into gate terminals of thin film transistors placed along the rows through the gate lines **241**, the thin film transistors are all turned on and the gray scale voltages which has been already applied to the data lines **242** are applied to the pixel electrodes. This generates an electric field proportional to the gray scale voltage, between the pixel electrode and the common electrode.

As the voltages are applied to the pixel electrodes, the liquid crystal interposed between the pixel electrode and the common electrode re-arranges and the light transmittance changes accordingly. As a result, lights may pass through the TFT substrate **240** depending on the light transmittance. Thereafter, the lights pass through the RGB elements formed on the color filter substrate **250** and displays an image. At this time, the electric field between the pixel electrode and the common electrode is maintained for a period of one frame in which all the gate lines **241** are turned on in order.

The above-described operations are performed very quickly and, thus, the liquid crystal display appears to display information in full color.

The gate driving signals processed in the single integrated PCB **260** are input into all the gate lines **241** via the double functioning tape carrier package **226**, the gate tape carrier package **210**, and the gate driver IC **212**.

Then, the transmission pattern and the transmission lines applied to the TFT substrate **240**, the gate tape carrier package **210**, the dual functioning tape carrier package **226** are formed in a very small space with a fine pitch. This fine pitch pattern and line may form a RC time delay circuit due to a very high resistance of the substrate and the parasitic capacitance formed between the gate transmission lines.

The RC time delay circuit may also cause the turn-on voltage Von and the turn-off voltage Voff of the gate driving signals to be modulated. A delay in transmission of the gate driving signals degrade the picture quality, causing flickers in the effective display region of the panel and a divisional appearance on the effective region of the panel.

Moreover, the modulation in the turn-on voltage and the turn-off voltage affects the gray scale voltage being input into the data lines **242**, resulting in a variation in the gray scale. In other words, both of the gate driving signal delay and the modulation in the turn-on and turn-off voltages significantly degrades the picture quality and display colors.

In order to prevent the gate driving signal transmission delay and the modulation of the turn-on voltage and the turn-off voltage, the resistance between the transmission pattern and the transmission lines needs to be decreased. The resistance can be theoretically decreased by enlarging the sectional area of the gate driving signal transmission line and the gate driving signal pattern or sufficiently widening the interval between the gate driving signal transmission lines.

However, such a conventional wisdom consumes the scarce resource of real estate on the TFT substrate **240**, making it more difficult to produce a compact and lighter LCD product.

Accordingly, several preferred embodiments are disclosed to resolve such drawbacks. They are described with reference to the accompanying drawing of FIG. **5**.

As described referring to FIGS. **2** to **6**, the first gate driving signal transmission line **247**, the gate driving signal transmission pattern **223**, the gate driving signal input pattern **213**, the first gate output pattern **214** are grouped in plurality. For example, three gate driving signal line groups comprise a first gate driving signal line group **281**, a second gate driving signal line group **282**, and a third gate driving signal line group **283**. Each of the three groups has a plurality of signal transmission lines.

A plurality of gate driving signals are transferred through the respective corresponding gate driving signal line groups **281**, **282**, and **283** into the respective corresponding gate driver ICs **212**. Here, it is natural for the single integrated PCB **260** to have additional output terminals A, B, and C which are connected to the respective gate driving signal transmission groups.

Specifically, the first gate driving signal lines group **283** is connected to the first gate driver IC of the first gate tape carrier package, the second gate driving signal line group

282 is connected to the second gate driver IC of the second gate tape carrier package, and the third gate driving signal line group 281 is connected to the third gate driver IC of the third gate tape carrier package.

In other words, the plurality of gate driving signal transmission lines are grouped into several groups and respective groups are connected to corresponding gate driver ICs in parallel, thereby minimizing the RC time delay during the transmission of the gate driving signals and preventing the flicker and picture division appearance.

As another embodiment, upon considering the length of the respective gate driving signal lines from the single integrated PCB 260, the first gate driving signal line group 281 is longer than the second gate driving signal line group 282. And the second gate driving signal line group 282 is longer than the third gate driving signal line group 283. In the above constitution, since resistance of the lines groups is proportional to the length, the first gate driving signal lines group 281 has the biggest resistance when the diameter of the lines of the respective groups are the same. Therefore, in order to prevent RC time delay due to a difference in the resistance between the three gate driving signal lines, the diameter of each of signal transmission lines of the first gate driving signal line group is bigger than the second gate driving line group and the diameter of each of signal transmission lines of the second gate driving signal line group is bigger than the third gate driving line group.

Another embodiment to prevent the flicker and the picture division appearance phenomena applies respective gate driving signals corresponding to the respective gate driving signal line groups 281, 282, and 283 to the corresponding gate driving signal line groups 281, 282, and 283 with a time interval. A first gate driving signal corresponding to the first gate driving signal line group 281 is first applied to the first gate driving signal line group 281. A second gate driving signal corresponding to the second gate driving signal line group 282 is secondly applied to the second gate driving signal line group 282 after a first predetermined time elapses after sending the first gate driving signal. Then, a third gate driving signal corresponding to the third gate driving signal line group 283 is finally applied to the third gate driving signal line group 283 after a second predetermined time elapses after sending the second gate driving signal. The first and second predetermined time is determined by respective resistance values calculated considering the lengths and diameters of the first, second, and third gate driving signal line groups 281, 282, and 283.

As still another embodiment to prevent the flicker and the picture division appearance problems, respective gate driving signal line groups 281, 282 and 283 are electrically connected to respective corresponding gate driver ICs in parallel and a turning resistor that controls the timing of the gate driving signals is connected to the respective gate driving signal line groups 281, 282, and 283 or the single integrated PCB 260.

Specifically, Voff signal that turns off the thin film transistor proves to be sensitively affected by the substrate resistance and the signal transmission patterns. As described previously, since the substrate resistance and the pattern resistance are determined by the total length and the diameter of the gate driving signal line groups 281, 282, and 283, the gate driving signal line groups have different signal arriving time, generating the flicker and the picture division appearance problems and degrading the picture quality.

Therefore, the single integrated PCB 260 generates the Voff signal considering maximum resistance among the resistances applied to the gate driving signal line groups 281, 282, and 283.

However, although the Voff signal is input into respective gate driver ICs through the respective corresponding gate driving signal line groups 281, 282, and 283 considering the maximum resistance, the final Voff signal still has a deviation due to the resistance. Accordingly, in order to eliminate the deviation, a turning resistor is provided.

The turning resistor is respectively formed in each of the gate driving signal line groups 281, 282, and 283 and enables to output a Voff signal with a minimum deviation, thereby eliminating the flicker and the picture division appearance problems.

Next, a method for operating the LCD panel according to the above preferred embodiments is described.

First, the single integrated PCB 260 generates a gate driving signal and a data driving signal. The data driving signal is transformed into a source signal including a gray scale voltage through the dual functioning data tape carrier package 226 and the single functioning data tape carrier package 229. The source signal is then applied to the data line group 246.

The gate driving signals from the single integrated PCB 260 are concurrently input to all the gate driver ICs 212 of the gate tape carrier packages 210 through the first gate driving signal line group 281 to the third gate driving signal line group 283.

The first corresponding gate driving IC receives a first gate driving signal from the single integrated PCB 260 through the third gate driving signal lines group 283 and then applies Von signals to gate lines in portion of "I" of the effective display region in FIG. 5 using OE signal. The image of the portion "I" is maintained for one frame.

The second corresponding gate driving IC receives a second gate driving signal from the single integrated PCB 260 through the second gate driving signal line group 282 and then applies Von signals to gate lines in portion "II" of the effective display region in FIG. 5. The picture of the portion "II" is also maintained for one frame together with the picture of the portion "I".

The third corresponding gate driving IC receives a third gate driving signal transmitted from the single integrated PCB 260 through the first gate driving signal line group 281 and then applies Von signals into gate lines in portion "III" of the effective 21. display region in FIG. 5. The picture of the portion "III" is also maintained for one frame together with the picture of the portion "I" and portion "II".

Because these steps are performed very quickly, it may display a moving picture or a clean still picture on the panel.

The liquid crystal display panel according to the present invention does not need a gate PCB and only the gate tape carrier packages 210 are coupled to the ends of the gate lines 241 formed on the TFT substrate 240.

Thus, these gate tape carrier packages 210 are bent and then attached to the rear surface of the TFT substrate 240 as shown in FIGS. 6 and 7. This would produce a compact liquid crystal display panel.

FIG. 8 is a partial sectional view that can be handled easily showing a part of a liquid crystal display according to the present invention.

Referring to FIG. 8, a backlight assembly 300 includes a mold frame 350. The mold frame 350 receives a light reflecting plate 340, a light guiding plate 320, and optical sheets 310 in the named order. The liquid crystal panel of the

present invention is mounted on the optical sheets **310** and the perimeter region of the liquid crystal panel **200** is fixed by a chassis **400**.

Here, a tape carrier package **210** one end of which is connected to the TFT substrate **240** is bent and a gate driver IC **212** of the tape carrier package **210** is attached to the rear surface of the TFT substrate **240** by a fixing means such as a double sided adhesive tape, an adhesive, or a clip.

The mold frame **350** has a receiving groove **350***a* that can accommodate the tape carrier package **210**.

Meanwhile, although the above described embodiments show and describe the tape carrier packages of the above-described configurations, a chip on flexible (COF) having more flexible base film than the base film of the flexible printed circuit may be also used.

Also, although FIG. **4** shows and describes that the gate driving signal transmission pattern **223** is integrated together with both of the data driving signal input pattern **224** and the data driving signal output pattern **225** on the data tape carrier package **226** of FIG. **4**, only the gate driving signal transmission pattern **223** may be formed on an independent flexible base no having a driving chip.

As described above, the present invention can provide a compact size liquid crystal display by integrally processing gate and data driving signals using a single integrated PCB.

Moreover, using the single integrated PCB may eliminate the connector and a flexible printed circuit that is used for connecting two PCBs. As a result, spaces for the connector and the flexible printed circuit can be saved. Also, the whole assembly process is simplified.

While the present invention has been described in detail, it should be understood that various changes, substitutions and alterations can be made hereto without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A liquid crystal display (LCD) panel, comprising:

a substrate;

a gate line and a data line formed on the substrate;

a gate driving signal transmission pattern formed on the substrate and connected to the gate line for transmitting a gate driving signal thereto;

a data driving signal transmission pattern formed on the substrate and connected to the data line for transmitting a data driving signal thereto; and,

a gate signal transmission pattern formed on the substrate adjacent to the data driving signal transmission pattern for transmitting a gate signal from a first external device to the gate driving signal transmission pattern.

2. The LCD of claim **1**, wherein:

the substrate comprises a display region in which the data line and the gate line intersect each other, and a peripheral region formed around the display region, and,

the gate driving signal transmission pattern, the data driving signal transmission pattern and the gate signal transmission pattern are formed in the peripheral region.

3. The LCD panel of claim **2**, wherein the peripheral region comprises a first edge portion formed along a first side of the substrate and a second edge portion formed along a second side of the substrate adjacent to the first side, and,

the data driving signal transmission pattern is formed on the first edge portion, the gate driving signal transmission pattern is formed on the second edge portion, and,

the gate signal transmission pattern is formed extending from the first edge portion to the second edge portion.

4. The LCD panel of claim **3**, wherein the gate signal transmission pattern comprises:

an input terminal formed on the first edge portion;

an output terminal formed on the second edge potion; and,

a main signal pattern coupled between the input terminal and the output terminal.

5. The LCD panel of claim **4**, wherein the input terminal of the gate signal transmission pattern and the data driving signal transmission pattern are formed adjacent to each other.

6. The LCD panel of claim **4**, wherein the input terminal of the gate signal transmission pattern and the data driving signal transmission pattern are connected to the first external device.

7. The LCD panel of claim **6**, wherein the first external device transmits the gate signal and the data driving signal to the gate signal transmission pattern and the data driving signal transmission pattern, respectively.

8. The LCD panel of claim **7**, wherein the first external device receives a data signal and generates the data driving signal.

9. The LCD panel of claim **8**, wherein the first external device comprises a driving circuit for generating the data driving signal.

10. The LCD panel of claim **7**, wherein the first external device is a tape carrier package.

11. The LCD panel of claim **4**, wherein the output pattern of the gate signal transmission pattern and the gate driving signal transmission pattern are formed adjacent to each other.

12. The LCD panel of claim **4**, wherein the output pattern of the gate signal transmission pattern and the gate driving signal transmission pattern are connected to a second external device.

13. The LCD panel of claim **12**, wherein the second external device receives the gate signal from the gate signal transmission pattern and generates the gate driving signal.

14. The LCD panel of claim **13**, wherein the second external device comprises a driver circuit for generating the gate driving signal.

15. The LCD panel of claim **14**, wherein the second external device is a tape carrier package.

16. The LCD panel of claim **4**, wherein the main signal pattern of the gate signal transmission pattern is formed along the first side and the second side of the substrate.

17. A liquid crystal display (LCD) panel, comprising:

a substrate comprising:

a display region; and,

a peripheral region formed around the display region;

a first line formed in the display region for transmitting a first driving signal;

a second line formed in the display region and intersecting the first line for transmitting a second driving signal;

a first driving signal transmission pattern formed in the peripheral region and connected to the first line for transmitting the first driving signal thereto;

a second driving signal transmission pattern formed in the peripheral region and connected to the second line for transmitting the second driving signal thereto; and,

a first signal transmission pattern formed in the peripheral region adjacent to the first driving signal transmission pattern for transmitting a first signal to the second driving signal transmission pattern.

18. The LCD panel of claim **17**, wherein the peripheral region comprises a first edge portion formed along a first side of the substrate and a second edge portion formed along a second side of the substrate adjacent to the first side, the

first driving signal transmission pattern is formed on the first edge portion and the second driving signal transmission pattern is formed on the second edge portion, and,

the first signal transmission pattern is formed extending from the first edge portion to the second edge portion.

19. The LCD panel of claim **18**, wherein the first signal transmission pattern comprising:

an input terminal formed on the second edge portion;

an output terminal formed on the first edge portion; and,

a main pattern formed along the first side and the second side of the substrate.

* * * * *

Exhibit 4

US006937311B2

(12) **United States Patent**
Song et al.

(10) **Patent No.: US 6,937,311 B2**
(45) **Date of Patent: *Aug. 30, 2005**

(54) **LIQUID CRYSTAL DISPLAY HAVING DOMAIN DIVIDERS**

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(73) Assignee: **Samsung Electronics Co., Ltd.**, Suwon (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/861,397**

(22) Filed: **Jun. 7, 2004**

(65) **Prior Publication Data**

US 2004/0218132 A1 Nov. 4, 2004

Related U.S. Application Data

(63) Continuation of application No. 10/269,861, filed on Oct. 15, 2002, now Pat. No. 6,778,244, which is a continuation of application No. 10/020,303, filed on Dec. 18, 2001, now Pat. No. 6,512,568, which is a continuation of application No. 09/314,293, filed on May 19, 1999, now Pat. No. 6,342,938.

(30) **Foreign Application Priority Data**

May 19, 1998 (KR) 98-18037

(51) **Int. Cl.**[7] **G02F 1/1337**; G02F 1/1343

(52) **U.S. Cl.** **349/129**; 349/130; 349/139; 349/141; 349/143

(58) **Field of Search** 349/129, 130, 349/139, 141, 143, 145

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Primary Examiner—Tarifur R. Chowdhury
(74) *Attorney, Agent, or Firm*—McGuireWoods LLP

(57) **ABSTRACT**

A tetragonal ring shape aperture is formed in the common electrode on one substrate and a cross shape aperture is formed at the position corresponding to the center of the tetragonal ring shape aperture in the pixel electrode on the other substrate. A liquid crystal layer between two electrodes are divided to four domains where the directors of the liquid crystal layer have different angles when a voltage is applied to the electrodes. The directors in adjacent domains make a right angle. The tetragonal ring shape aperture is broken at midpoint of each side of the tetragon, and the width of the aperture decreases as goes from the bent point to the edge. Wide viewing angle is obtained by four domains where the directors of the liquid crystal layer indicate different directions, disclination is removed and luminance increases.

20 Claims, 12 Drawing Sheets

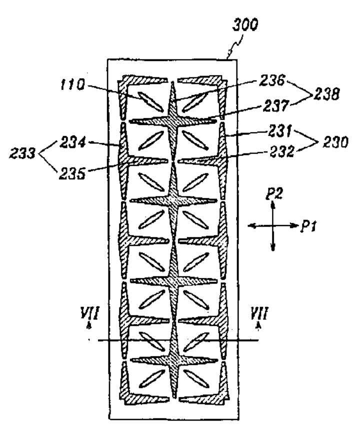


FIG. 1A

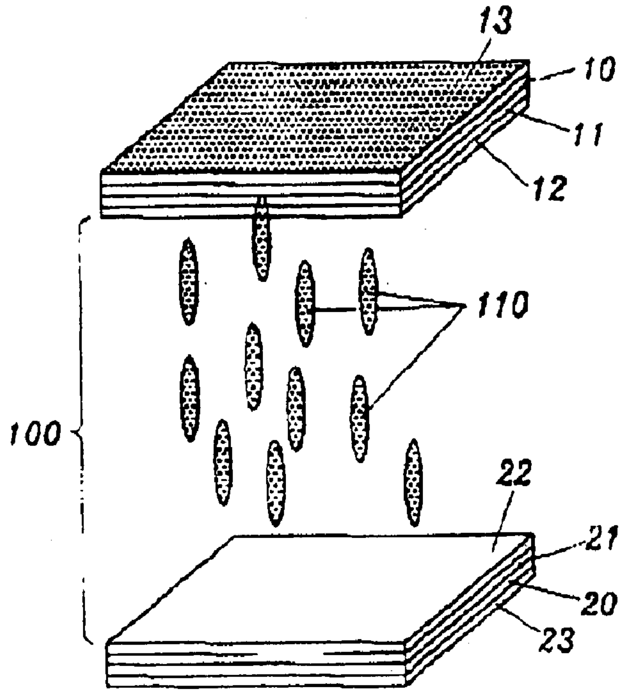


FIG. 1B

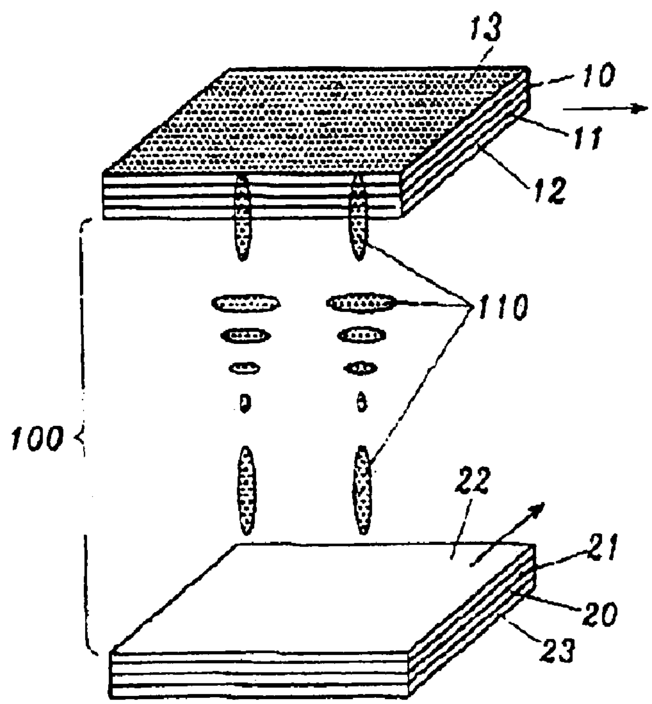


FIG. 2

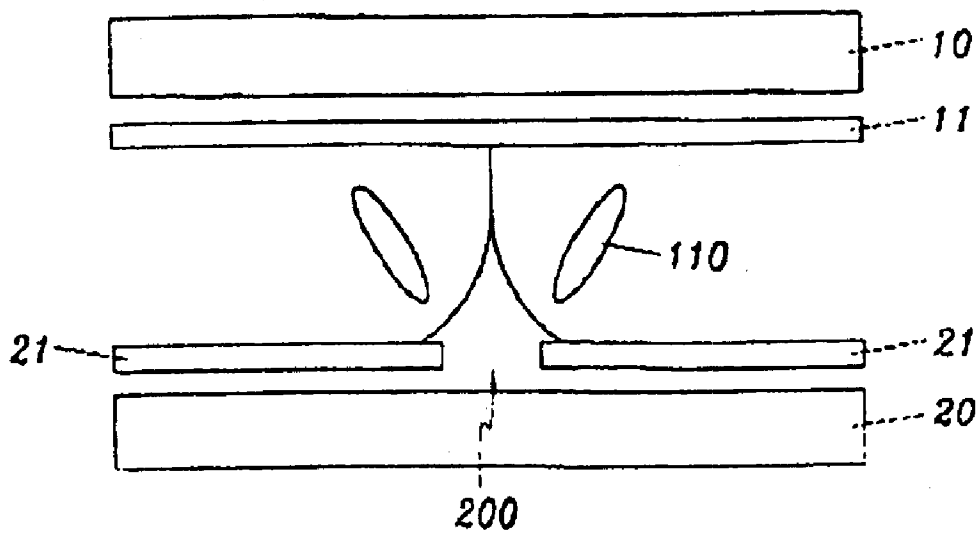


FIG. 3

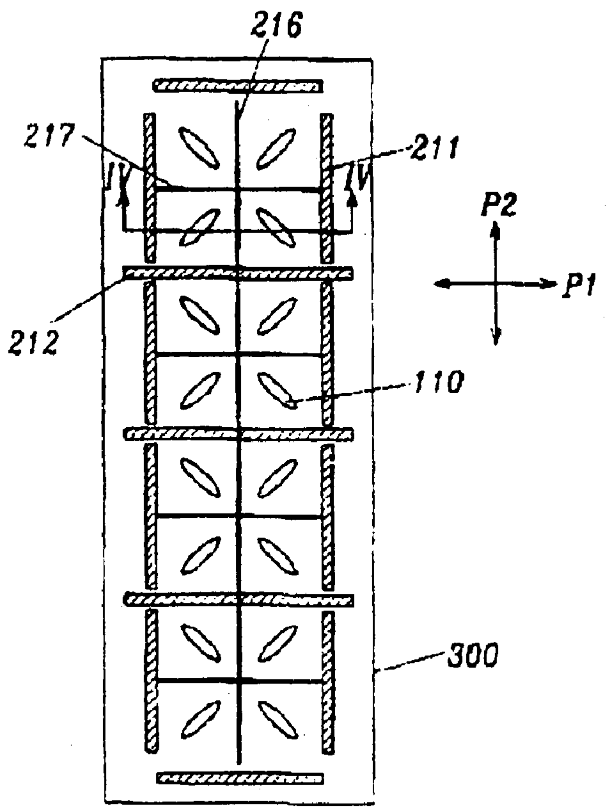

216
217
211
IV
IV
P2
P1
212
110
300

FIG. 4

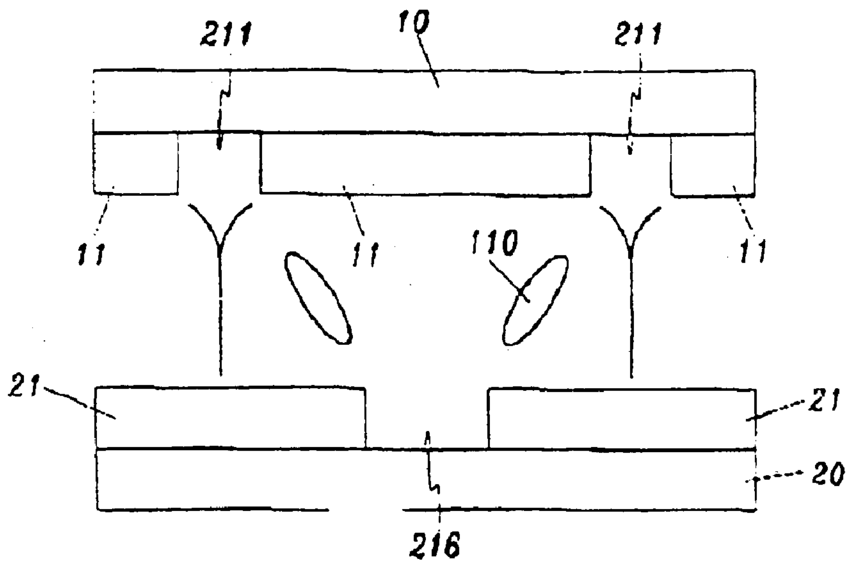

211
10
211
11
11
110
11
21
21
20
216

FIG.5

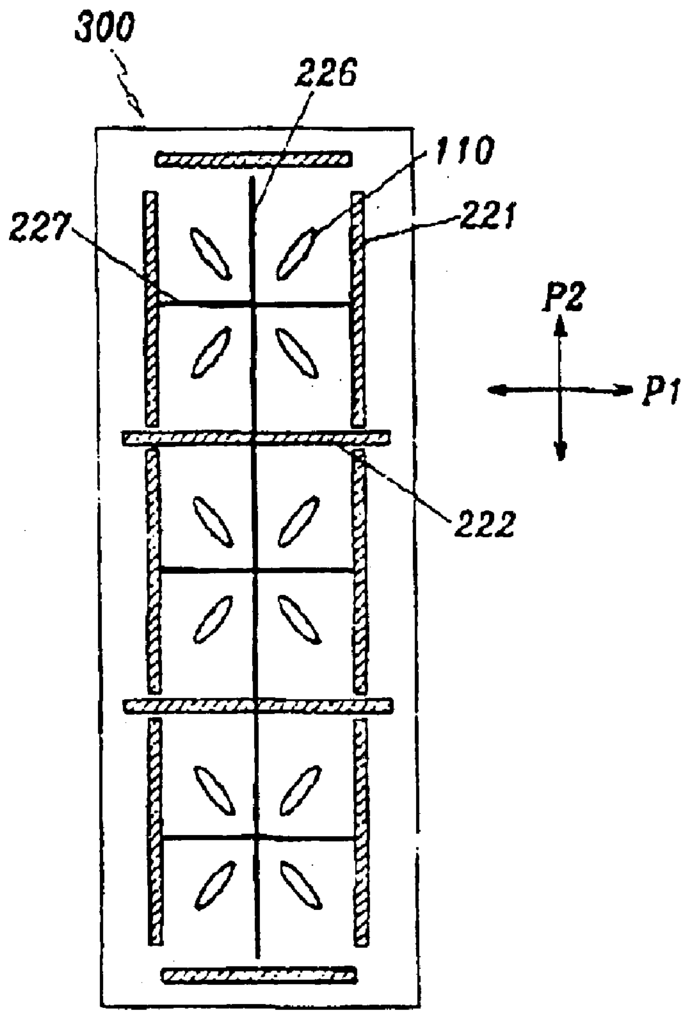


FIG.6

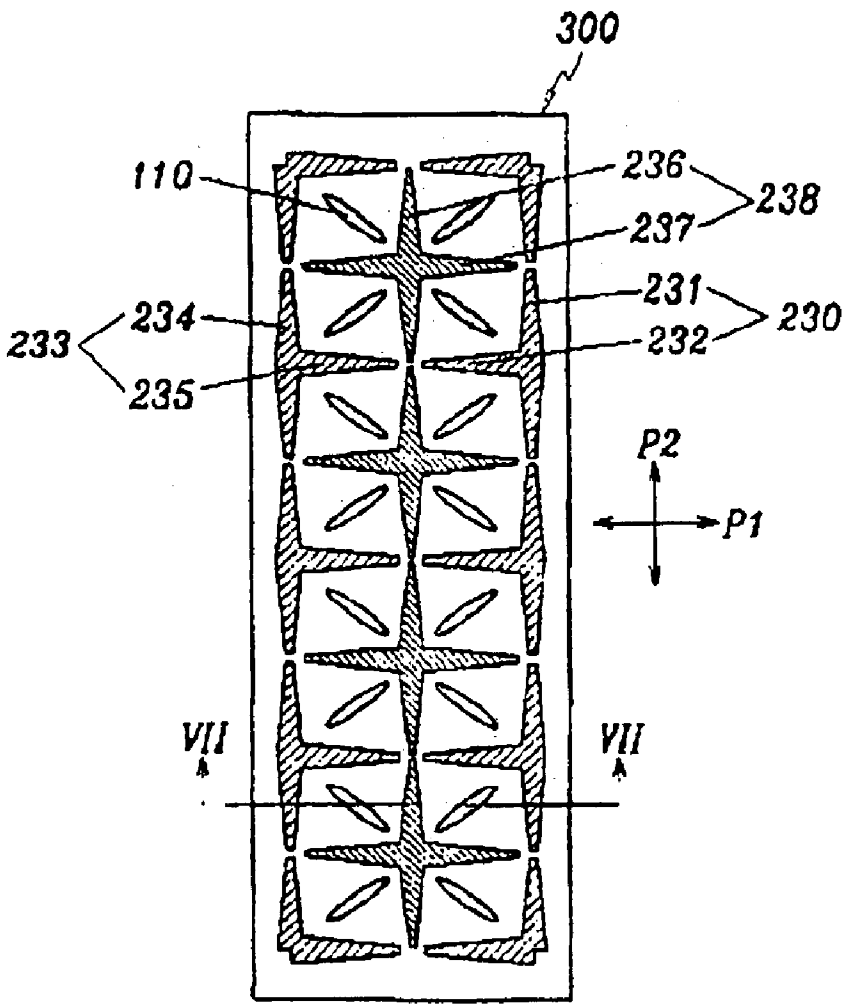


FIG. 7

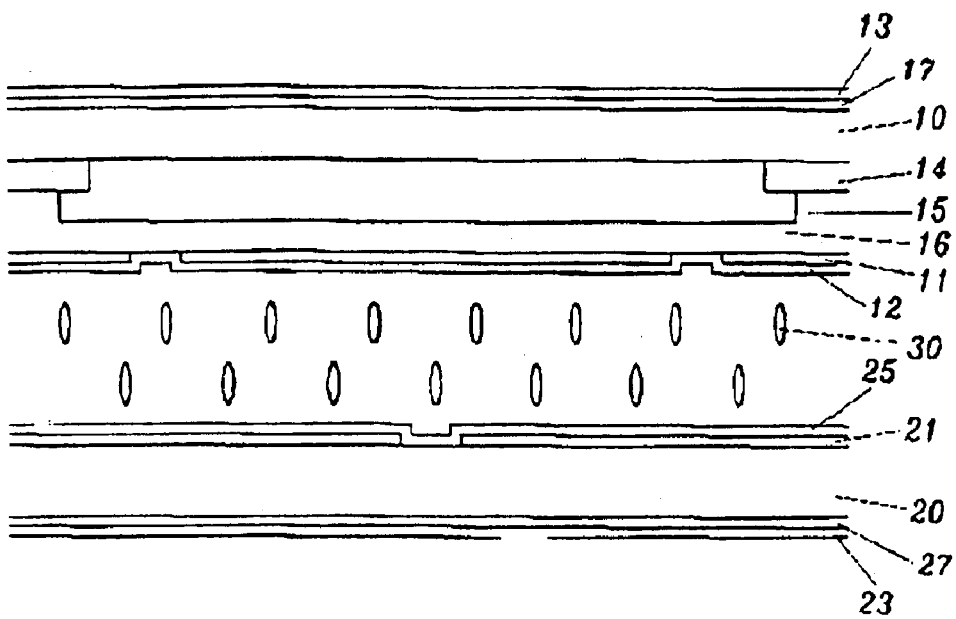


FIG. 8

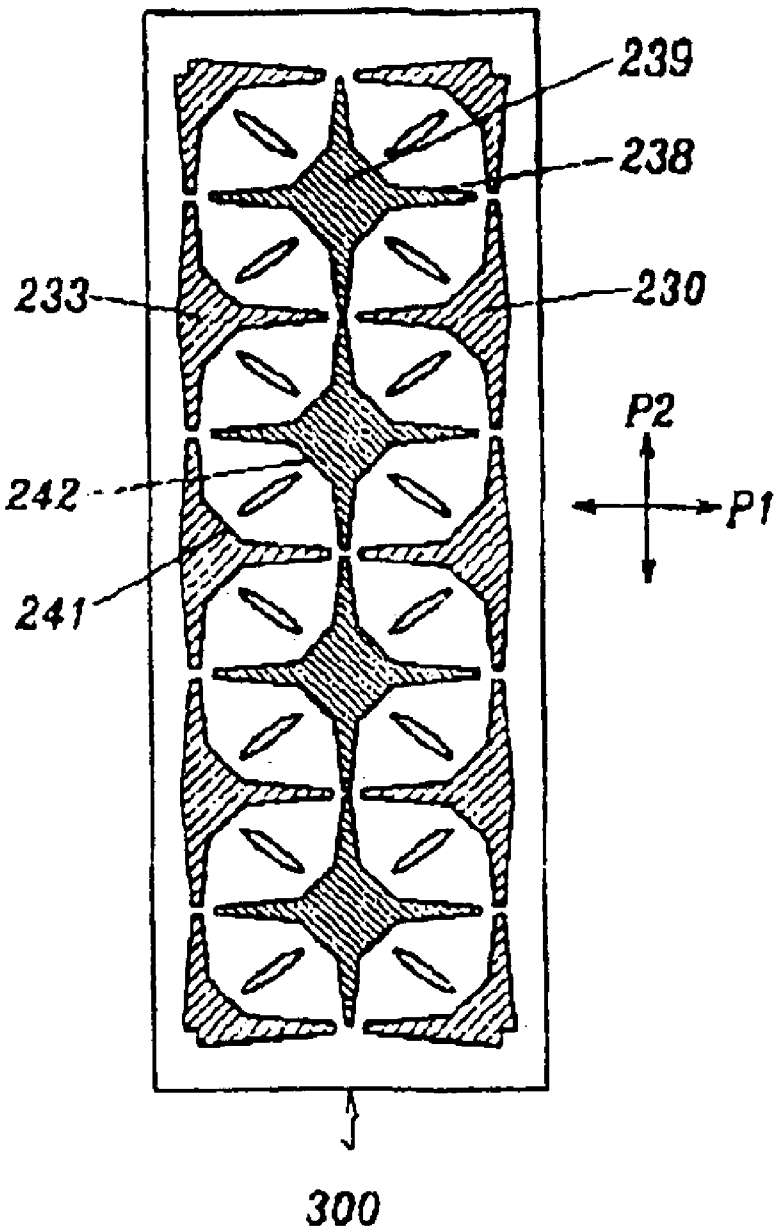


FIG. 9

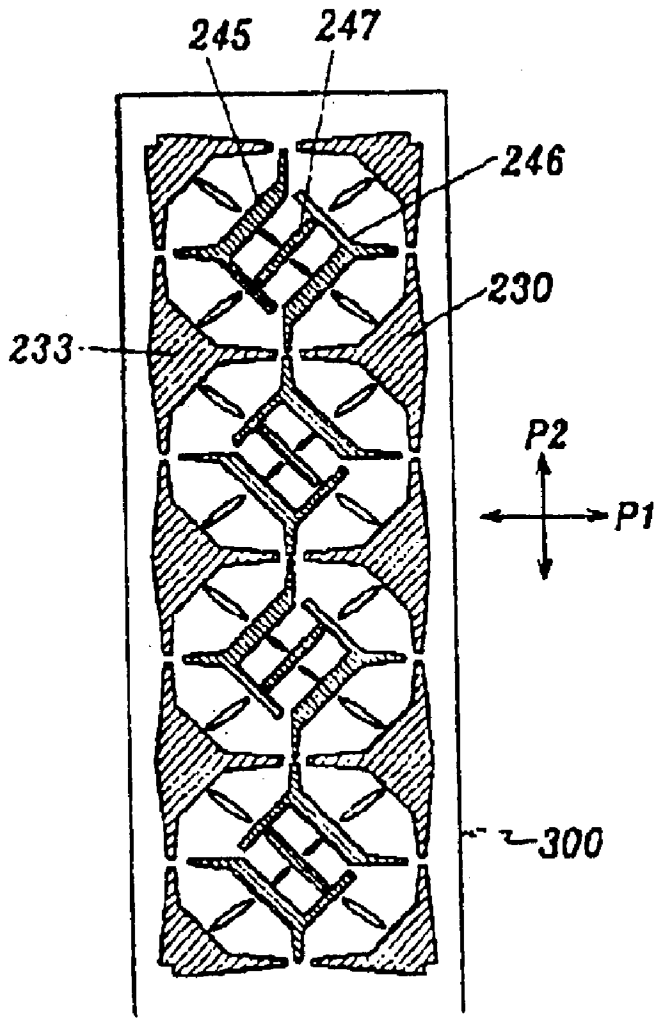


FIG. 10

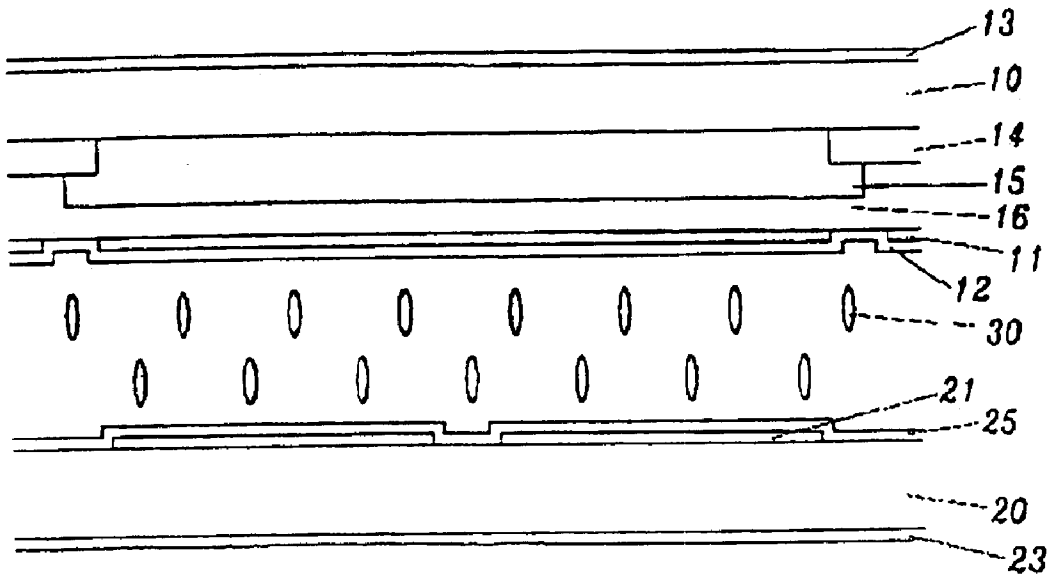
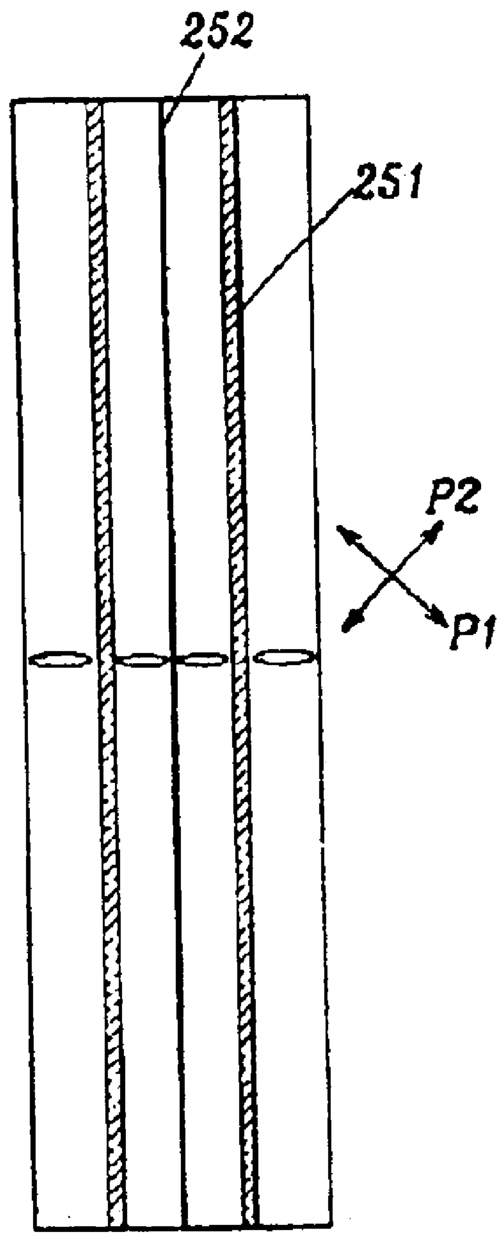


FIG. 11



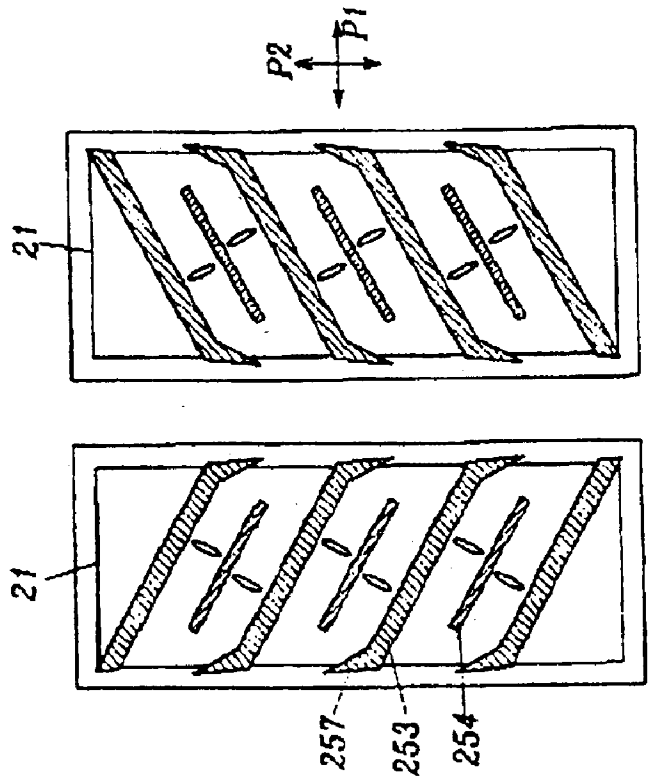


FIG. 13

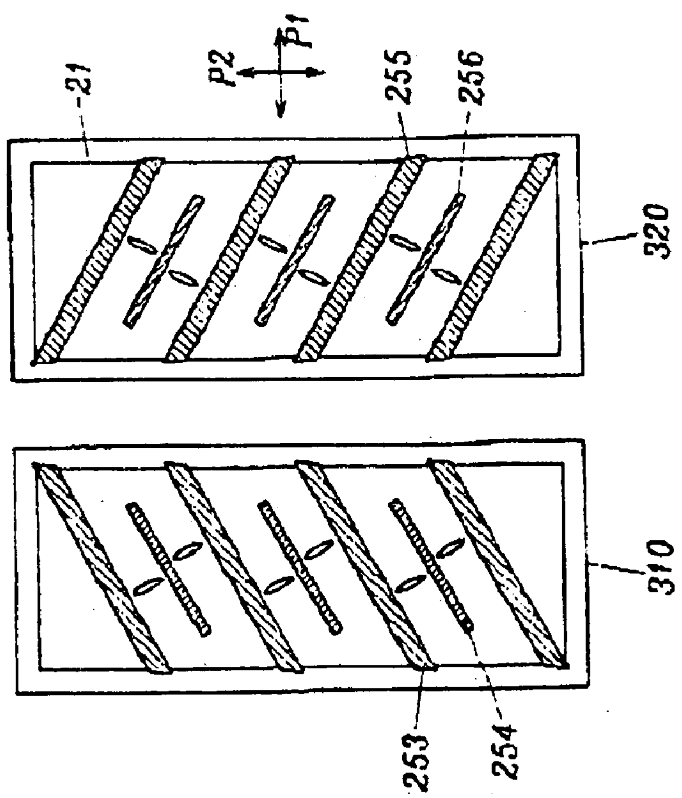


FIG. 12

FIG. 14

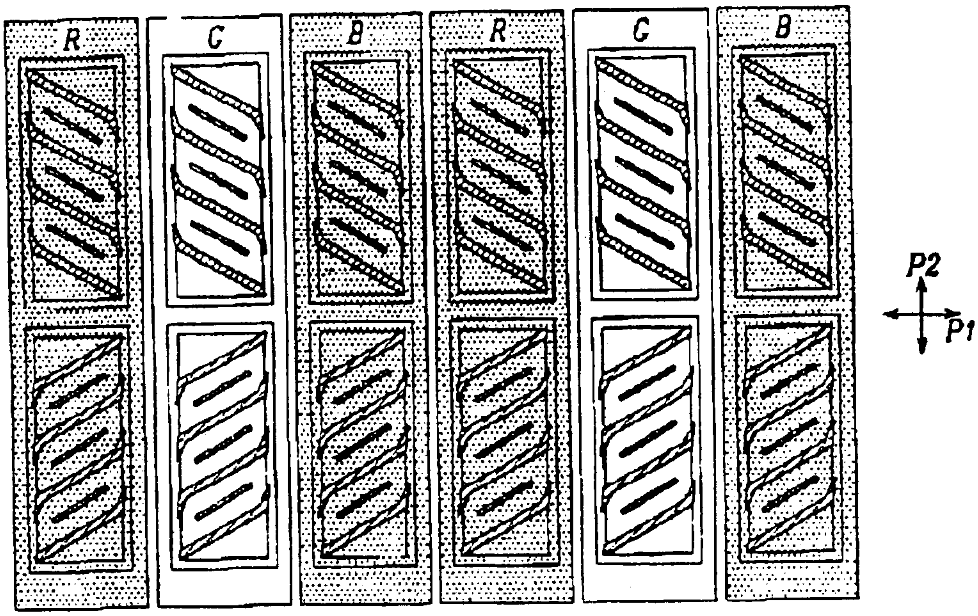
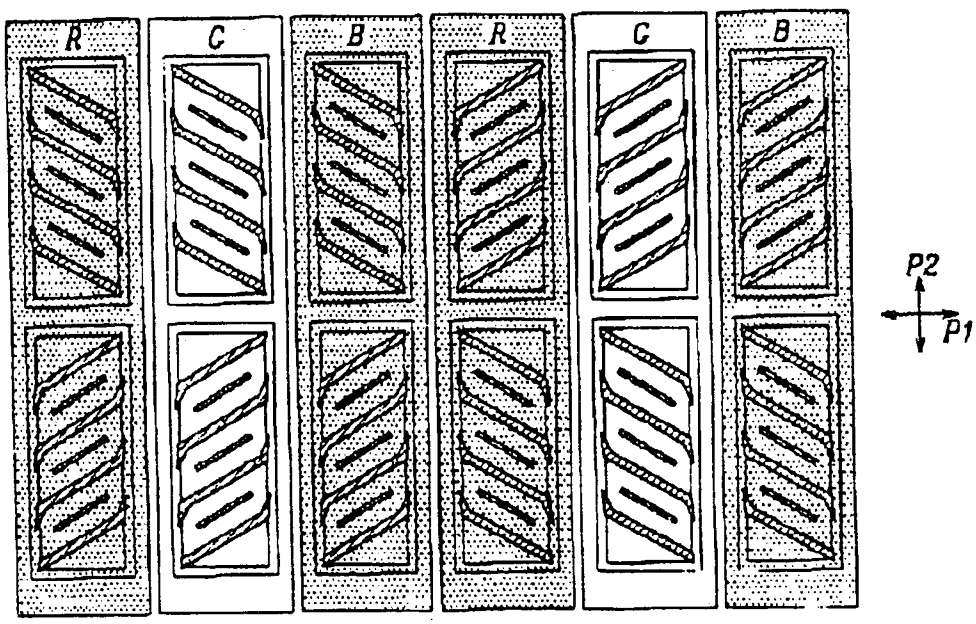


FIG. 15



LIQUID CRYSTAL DISPLAY HAVING DOMAIN DIVIDERS

CROSS REFERENCE

This application is a continuation application of Applicant's U.S. patent application Ser. No.10/269,861 filed on Oct. 15, 2002 now U.S. Pat. No. 6,778,244, which is a continuation of U.S. patent Ser. No. 10/020,303 filed on Dec. 18, 2001, now U.S. Pat. No. 6,512,568, which is a continuation of U.S. patent No.6,342,938.

BACKGROUND OF THE INVENTION

(a) Field of the Invention

The present invention relates to a liquid crystal display having wide viewing angle.

(b) Description of the Related Art

A liquid crystal display (LCD) includes two substrates and a liquid crystal layer interposed therebetween. The transmittance of the incident light is controlled by the strength of the electric field applied to the liquid crystal layer.

A vertically aligned twisted nematic (VATN) liquid crystal display has a couple of transparent substrates which have transparent electrodes on their inner surfaces and a couple of polarizers attached to their outer surfaces. The VATN LCD further includes a liquid crystal layer between the two substrates, and the liquid crystal layer has chirality and negative dielectric anisotropy.

In the off state of the LCD, i.e., in the state that no voltage is applied to the electrodes, the long axes of the liquid crystal molecules are aligned perpendicular to the substrates.

When the sufficient voltage difference is applied to the electrodes, an electric field perpendicular to the substrates and the liquid crystal molecules are rearranged. That is, the long axes of the liquid crystal molecules tilt in a direction perpendicular to the field direction or parallel to the substrates due to the dielectric anisotropy, and twist spirally with a pitch due to the chirality.

As described above, since the long axes of the liquid crystal molecules in the off state is perpendicular to the substrates, the VATN LCD having crossed polarizers may have sufficiently dark state. Therefore, the contrast ratio of the VATN LCD is relatively high compared with the conventional TN LCD. However, the viewing angle of the VATN LCD may not be so wide due to the difference in retardation values among viewing directions.

To overcome the above-described problem, multi-domain structures formed by varying rubbing directions in the alignment layers or by forming apertures in the transparent electrodes are proposed. Clere disclosed a structure having linear apertures in a transparent electrode in U.S. Pat. No. 5,136,407, and Hirose et al. disclosed an LCD using fringe fields to make the long axes of the liquid crystal molecules to be aligned in a direction between polarizing directions in U.S. Pat. No. 5,229,873. On the other hand, Lien proposed a structure having X-shaped apertures in a transparent electrode in U.S. Pat. No. 5,309,264, and Histake et al. disclosed a structure having apertures in both of the electrodes in U.S. Pat. No. 5,434,690.

However, the proposed structures may not have a sufficiently wide viewing angle and the luminance in their on states is not so high.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to widen the viewing angle of an LCD.

It is another object of the present invention to reduce the disclination of an LCD.

These and other objects, features and advantages are provided, according to the present invention, by forming apertures in field generating electrodes.

In detail, a liquid crystal display according to the present invention includes a first and a second substrate facing each other and a first and a second electrodes on inner surfaces of the first and the second substrates respectively. The first and the second electrodes face each other, and have a plurality of first apertures and a plurality of second apertures, respectively.

According to an aspect of the present invention, the first and the second apertures form a substantially closed area.

According to another aspect of the present invention, the boundaries of the first and the second apertures are linear, curved or bent with an obtuse angle.

According to another aspect of the present invention, the width of the first and the second apertures becomes larger as goes from the ends to the center.

According to another aspect of the present invention, the width of the first and the second apertures are 3–20 μm.

According to another aspect of the present invention, the distance between the first and the second apertures are 5–20 μm.

The liquid crystal display according to the present invention may include a liquid crystal layer between the first and the second substrates, a first and a second alignment layers on the first and the second electrodes, respectively, and a first and a second polarizers attached on the outer surfaces of the first and the second substrates, respectively. The liquid crystal layer has negative dielectric anisotropy, and the first and the second alignment layer force the long axes of the liquid crystal molecules to align perpendicular to the first and the second substrates. The polarizing directions of the first and the second polarizers are preferably perpendicular to each other. It is preferable that the number of the average directions of the long axes of the liquid crystal molecules in the domains defined by the first and the second apertures are four. Preferably, the average directions makes 45°±10° with the polarizing directions of the first and the second polarizers, and the average directions of the adjacent domains are substantially perpendicular to each other.

The shape of the first and the second electrodes according to the present invention makes the liquid crystal layer therebetween to be divided into four regions having different average directions of the long axes, thereby causing wide viewing angle. In addition, disclination due to the disorder of the liquid crystal molecules is reduced by adjusting the widths and shapes of the apertures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A and **1**B are schematic diagrams of a VATN LCD according to an embodiment of the present invention, respectively in black state and white state.

FIG. **2** is a schematic sectional view of a VATN LCD according an embodiment of the present invention

FIG. **3** is a layout view of apertures in electrodes of a VATN LCD according to the first embodiment of the present invention.

FIG. **4** is a sectional view of a liquid crystal display taken along the line IV—IV in FIG. **3**.

FIG. **5** is a layout view of apertures in electrodes of a VATN LCD according to the second embodiment of the present invention.

FIG. **6** is a layout view of apertures in electrodes of a VATN LCD according to the third embodiment of the present invention.

FIG. **7** is a sectional view of a liquid crystal display taken along the line IV—IV in FIG. **6**.

FIGS. **8** and **9** are layout views of apertures in electrodes of VATN LCDs according to the fourth and fifth embodiments of the present invention.

FIG. **10** is a sectional view of a liquid crystal display according to an embodiment of the present invention.

FIGS. **11** to **15** are layout views of apertures in electrodes of VATN LCDs according to the sixth to tenth embodiments of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the present invention are shown. This invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the thickness of layers and regions are exaggerated for clarity.

FIGS. **1**A and **1**B are schematic diagrams of a VATN LCD according to an embodiment of the present invention, respectively in black state and white state.

As shown in FIGS. **1**A and **1**B, two glass or quartz insulating substrates **10** and **20** faces each other with being spaced apart from each other. Field generating electrodes **11** and **21** made of a transparent conductive material such as ITO (indium tin oxide) or the like are formed on the inner surfaces of the substrates **10** and **20**, respectively, and homeotropic alignment layers **12** and **22** are formed thereon, respectively. A liquid crystal layer **100** including a nematic liquid crystal having negative dielectric anisotropy is interposed between the substrates **10** and **20**. The liquid crystal layer **100** may have chirality or the alignment layers **12** and **22** may be rubbed in some directions so that the director of the liquid crystal layer **100** twists from the one alignment layer to the other. Polarizers **13** and **23** are attached on the outer surfaces of the substrates **10** and **20**, respectively, and polarize the rays out of the liquid crystal layer **100** and the rays incident on the liquid crystal layer **100**, respectively. The polarizing directions of the polarizers **13** and **23** are perpendicular to each other. The alignment layers **12** and **22** may be rubbed or not.

FIG. **1**A shows the off state that there is no potential difference between the electrodes **11** and **21**. In this case, long axes or molecular axes of the liquid crystal molecules **110** in the liquid crystal layer **100** are aligned perpendicular to the surfaces of the substrates **10** and **20** due to the aligning force of the alignment layers **12** and **22**.

In this state, the incident light linearly polarized by the polarizer **23** attached to the lower substrate **20** passes through the liquid crystal layer **100** without changing its polarization. Then, the light is blocked by the analyzer **13** attached to the upper substrate **10** to make the LCD in a black state.

When the potential difference is applied between the two electrodes **11** and **21**, an electric field perpendicular to the substrates **10** and **20** are generated, and thus the liquid crystal molecules are rearranged.

FIG. **1**B shows the on state that the sufficient electric field due to the high potential difference between the electrodes **11** and **21** is applied to the liquid crystal layer **100**. The molecular axes of the liquid crystal molecules in the liquid crystal layer **100** becomes perpendicular to the field direction or parallel to the substrates **11** and **21** due to the dielectric anisotropy. However, the molecules **110** near the surface of the alignment layers **12** and **22** remains in its initial state since the aligning force by the alignment layers **12** and **22** is much larger than the force due to the dielectric anisotropy. Furthermore, the liquid crystal director twists spirally due to the chirality or rubbing. By adjusting the chirality of the liquid crystal layer **100**, the twist angle of the liquid crystal director from the lower substrate **10** to the upper substrate **20** may made to be 90°.

The incident light linearly polarized by the polarizer **23** passes through the liquid crystal layer **100** and its polarization rotates by 90° according to the twist of the liquid crystal director. Therefore, the light passes through the analyzer **13** to make the LCD in a white state.

FIG. **2** shows the schematic structure of a VATN LCD having apertures in electrodes according to an embodiment of the present invention. For convenience, only substrates and electrodes are depicted and the other elements such as alignment layers are abbreviated.

As shown in FIG. **2**, field-generating electrodes **11** and **21** are formed on the upper and the lower substrates **10** and **20**, respectively, and the electrode **21** formed on the lower substrate **20** has an aperture **200**.

In absence of electric field, the long axes of the liquid crystal molecules **110** are aligned perpendicular to the substrates **10** and **20**, as shown in FIG. **1**A.

If the electrodes **11** and **21** have potential difference, an electric field is generated. Although the field direction in most regions is perpendicular to the substrates **10** and **20**, the field direction near the aperture **200** is not completely perpendicular to the substrates **10** and **20**, and the electric field is symmetrical with respect to the aperture **100**. The electric field near the aperture **200** is called the fringe field. The long axes of the liquid crystal molecules are not perpendicular to the substrates **10** and **20** and make some angle. The arrangement of the liquid crystal molecules are almost symmetrical with respect to the aperture **200** and the liquid crystal molecules in opposite regions with respect to the aperture **200** are arranged in opposite manner, thereby causing wide viewing angle.

The strength of the fringe field is large near the aperture and becomes smaller as goes far from the aperture. Accordingly, if the distance between the apertures is properly adjusted, the liquid crystal molecules located between the apertures are sufficiently affected by the fringe field. The liquid crystal layer is divided into several regions or domains defined by the apertures, and the average axial direction, which means the average direction of the long axes of the liquid crystal molecules, in each domain is varied according to the shapes and arrangement of the apertures.

Since the aperture **200** is formed when a conductive layer is patterned to form the electrode **21** by using photolithography, no separate step for forming the aperture **20** is required, and thus it is very easy to obtain a multi-domain LCD compared with other methods using such as rubbing. In addition, the locations and the shapes of the domains can be finely adjustable because of the use of the photolithgraphy. In the meantime, a plurality of wires (not shown) for supplying signals to the electrode **21** may be provided on the lower substrate **20**. In this case, portions of

the electrode **11** on the upper substrate **10** located at the position corresponding to wires on the lower substrate **20** may be removed in order to reduce the parasitic capacitance between the electrode **11** and the wires.

As described above, the apertures **200** may have various shapes and arrangements, and the apertures may be formed in both electrodes or either of the electrodes. Since the shapes and arrangements of the apertures affects on the average axial directions of the domains and characteristics such as luminance, response time and afterimages, etc., of the LCD panels, they should be properly designed.

The aperture pattern for a multi-domain LCD according to the present invention satisfies the following conditions:

First, it is preferable that the number of the domains which have different average axial directions, especially in a pixel, is at least two, and more preferably the number is four. The average axial direction of each domain, when viewed from the top, preferably makes 45°±10°, more preferably 45° with the polarizing directions of the polarizers especially when using crossed polarizers. In addition, it is preferable that the average axial directions of the adjacent domains are perpendicular to each other.

Second, it is preferable that the apertures on the upper and the lower substrates form substantially closed areas and thus substantially closed domains, when viewed from the top. It is because that the texture where the arrangement of the liquid crystal molecules is disordered is generated near the ends of the apertures, and thus the ends of the apertures are preferably closely located. Furthermore, the boundaries of the apertures are preferably linear, slowly curved or bent with an obtuse angle in order to make the arrangement of the liquid crystal molecules to be uniform, thereby reducing the response time. In particular, when the apertures on the lower and upper substrates face each other and form a substantially closed area, it is preferable that the boundaries of the facing portions of the apertures are preferably linear, slowly curved or bent with an obtuse angle. It is preferable that the width of the aperture becomes larger as goes from the ends to the center. The aperture patterns may be rectangular.

Finally, the width of the aperture and the distance between the apertures are preferably 3–20 μm and 5–20 μm. If the width of the aperture is larger than the former value or the distance between the apertures is less than the latter value, the aperture ratio is reduced, thereby reducing luminance and transmittance. On the contrary, if the width of the aperture is less than the former value or the distance between the apertures is larger than the latter value, the strength of the fringe field becomes week, thereby increasing response time and generating disordered textures.

Now, considering these conditions, the first embodiment of the present invention will be described with reference to FIGS. **3** and **4**. Although an LCD has a plurality of pixels, FIGS. **3** and **4** show a single pixel region **300**. In addition, only aperture patterns are illustrated in FIGS. **3** and **4**, and other elements such as TFTs, wires, etc., are not illustrated.

As shown in FIGS. **3** and **4**, a plurality of linear apertures **211**, **212**, **216** and **217** are formed in a rectangular pixel region **300**. A plurality of first and second apertures **211** and **212** extending in transverse and longitudinal directions respectively are formed in an electrode **11** on an upper substrate **10**, and a cross-shaped aperture **216** and **217** including first and second portions **216** and **217** extending in the transverse and longitudinal directions respectively are formed in an electrode **21** on a lower substrate **20**.

The first and the second apertures **211** and **212** are separated from each other, arranged in the longitudinal direction, and form four large squares which is substantially closed.

The first portion **216** of the lower aperture passes through the center of the pixel **300** in the longitudinal direction, and thus through the center of the large squares formed by the first and the second apertures **211** and **212**, and both ends of the first portion **216** approaches the second apertures **212**. The plurality of second portions **217** passes through the center of the large squares in the transverse direction, and both ends of the second portion **216** approaches the first apertures **211**.

As a result, the apertures **211**, **212**, **216** and **217** form small squares which define domains, and two edges of the small square is two apertures **211** and **212** on the upper substrate **10**, while the other two edges of the small square is two apertures **216** and **217** on the lower substrate **20**.

The arrangement of the liquid crystal molecules is described with reference to FIG. **4**.

As shown in FIG. **4**, the liquid crystal molecules incline due to the fringe field near the apertures. The adjacent apertures **211** and **216** on the different substrates **10** and **20** result in a fringe field which forces the liquid crystal molecules between the apertures **211** and **216** to align in the same direction, i.e., the direction from the aperture **216** to the aperture **211**. Accordingly, the tilt directions of the liquid crystal molecules in the opposing regions with respect to the apertures are different.

In the meantime, since the adjacent apertures defining a domain are perpendicular to each other, the director of the liquid crystal layer varies in accordance with position. However, the average axial direction in a square domain becomes the direction from the intersection of the first and the second portions **216** and **217** to the intersection of the extensions of the first and the second apertures. That is, the average axial direction in a square domain is the direction from the center to the corner of the large square formed by the first and the second apertures **211** and **212**. This arrangement of the aperture makes sixteen square domains in a pixel, and the average axial direction of each domain is one of four directions. The average axial directions of the adjacent domains are perpendicular to each other when viewed from the top.

When the polarizing directions **P1** and **P2** of the polarizers are aligned in the transverse and the longitudinal directions respectively, the polarizing directions **P1** and **P2** have an angle of 45° relative to the average axial direction of each domain when a sufficient voltage is applied.

In the LCDs having the aperture pattern shown in FIG. **3**, the liquid crystal molecules are rearranged by the force due to the electric field immediately after the voltage is applied. However, the arrangement of the liquid crystal molecules is slowly changed by the tendency to be parallel to each other, which the molecules of the nematic liquid crystal have. Accordingly, it takes some time to reach a stable state that the movement of the liquid crystal molecules disappears, thereby causing large response time.

An aperture pattern according to the second embodiment of the present invention shown in FIG. **5** is similar to the aperture pattern shown in FIG. **3** except for rectangular shape of the domains instead of square shape. That is, longitudinal apertures **221** and **226** are longer than transverse apertures **222** and **227**. Accordingly, when viewed from the top, an angle made by the average axial directions in the adjacent domains is not exactly 90°, and an angle between the polarizing directions and the average axial directions is not exactly 45°. However, in this case, one of the transverse or longitudinal directions is preferred by the liquid crystal molecules because the long axes of the liquid

crystal molecules makes a less angle with one of the two directions than with the other. Since the rearrangement of the liquid crystal molecules quickly occurred and becomes stable, the response time is relatively short than the LCD shown in FIG. **3**.

A liquid crystal display exhibiting less response time is now described.

FIG. **6** is a layout view of an aperture pattern of an LCD according to a third embodiment of the present invention, and FIG. **5** is a sectional view of the LCD shown in FIG. **6** taken along the line VII–VII'.

As shown in FIGS. **6** and **7**, an LCD according to the third embodiment of the present invention includes a lower TFT (thin film transistor) panel **20** and an upper color filter panel **10**. Though it is not shown in the figures, a plurality of gate lines and data lines are formed on the inner surface of the TFT panel **20**, and a pixel electrode **20** and a TFT (now shown) as a switching element are formed in a lower pixel region surrounded by the gate lines and data lines. On the inner surface of the color filter panel **10** opposite to the TFT panel **20**, a black matrix pattern **14** which defines an upper pixel region corresponding to the lower pixel region in the TFT panel is formed, and a color filter **15** is formed therebetween. A passivation layer **16** covers the black matrix **14** and the color filter **15**, and a common electrode **11** is formed thereon. A plurality of apertures **230**, **233** and **238** are formed in the common electrode **11** and the pixel electrode **21**, and homeotropic alignment layers **25** and **15** are formed on the pixel electrode **21** and the common electrode **11**, respectively.

Polarizers **13** and **23** are attached to the outer surfaces of the substrates **10** and **20**, respectively, and retardation films **17** and **27** are interposed between the polarizers **13** and **23** and the substrates **10** and **20**, respectively. An a-plate compensation film and a c-plate compensation film may be attached to respective substrates, or two c-plate compensation films may be attached the both substrates **10** and **20**. A biaxial compensation film may be used instead of the uniaxial compensation film, and, in this case, the biaxial compensation film may be attached to only one substrate. The slow axis, which is the direction having a largest refractive index, of the a-plate or biaxial compensation film may be parallel or perpendicular to the polarizing directions. It is preferable that the second slow axis of the biaxial compensation film coincides the transmission or absorption axes of the polarizers.

The shapes of the apertures **230**, **233** and **238** are basically similar to those of the LCD shown in FIG. **3** according to the first embodiment. In detail, the apertures **230** and **233** on the color filter panel **10** includes longitudinal parts **231** and **234** and transverse parts **232** and **235** extending from the center of the longitudinal parts **231** and **233** in the left or right direction. The apertures **233** and **230** located near the left and right edges of the pixel is symmetrically arranged with respect to the longitudinal central line of the pixel, and form four large rectangles (almost squares) arranged in the longitudinal direction. The plurality of the apertures **238** on the TFT panel **20** have cross shapes including transverse parts **237** and longitudinal parts **236** crossing each other, and the centers of the apertures **238** are located at the center of the large rectangles.

It is preferable that the ends of the apertures **230**, **233** and **238** on the substrates **10** and **20** are as close as possible such that the domain defined by the apertures **230**, **233** and **238** form a substantially closed area when viewed from the top.

The width of the apertures **230**, **233** and **238** is largest at the center, and decreases as goes to the ends. Therefore, the boundaries of the apertures **230**, **233** and **238** are bent with obtuse angle, and the angle made by two apertures on the different substrates are acute angle when viewed from the top. As a result, the domain defined by the apertures **13** and **23** has the diagonal substantially perpendicular to the average axial direction which is longer than the diagonal substantially parallel to the average axial direction. The ratio of the diagonal perpendicular to the average axial direction with respect to the diagonal parallel to the average axial direction becomes larger if the width difference between the central portion and the end portion of the apertures **230**, **233** and **238** is more enlarged at the bent point. Since the liquid crystal molecules become more uniformly aligned as the apertures **13** and **23** are parallel to each other, the response time becomes reduced as the ratio becomes large.

In this embodiment, the average axial directions of the adjacent domains makes 90 degrees, and the polarizing directions P1 and P2 of the polarizers **13** and **23** are perpendicular to each other and makes 45 degrees with the average axial direction of each domain.

According to the third embodiment, four tetragonal rings formed of the apertures exist in a unit pixel. However, the number of the rings may vary according to the conditions such as the size of the pixel. Still, to obtain the optimum luminance, the apertures preferably form regular tetragonal rings.

The width of the apertures **230**, **233** and **238** is preferably in the range of 3–20 μm as described above.

The distance between the central points of the apertures **230**, **233** and **238** on the different substrates **10** and **20**, which is largest distance between the apertures, is in the range of 10–50 μm and more preferably in the range of 23–30 μm. However, it depends on the size or the shape of the pixel.

Now, a fourth embodiment of the present invention is described with reference to FIG. **8**.

As shown in FIG. **6**, the shape of apertures is similar to that of the third embodiment. However, the boundaries of the apertures **230**, **233** and **238** are bent twice while those in the third embodiment once, when only a domain is considered. In addition, considering only a domain, the edges **241** and **242** generated by the twice bending of the boundaries of the apertures **230**, **233** and **238** on the different substrates **10** and **20** are parallel to each other. In other words, the central portions of the apertures **230**, **233** and **238** expand to the center of the domain, the central portions **239** of the apertures **238** becomes square. Accordingly, the distance between the apertures **230**, **233** and **238** becomes much smaller, and the boundaries of the apertures **230**, **233** and **238** approaches linear shape, thereby decreasing response time. However, since the area occupied by the apertures **233**, **233** and **238** becomes larger, the aperture ratio decreases.

To solve this problem, the central portion **239** of the aperture **238** on the lower substrate **20** in the fourth embodiment becomes square ring instead of square in the fifth embodiment. The cross shaped aperture **238** is divided two portions **245** and **246** in order to prevent the isolation of the portion of the electrode surrounded by the central portion of the aperture **238**. That is, two adjacent edges of the square ring is connected to each other, but disconnected to the remaining two edges. Furthermore, an aperture **247** parallel to the opposing edges of the square ring is added. As a result, two domains are added in the square ring, and the aperture ratio increases.

In the first to the fifth embodiments of the present invention, aperture ratio and luminance may be improved if

edge portions of the apertures **230** and **233** on the upper substrate **10** are placed outside the pixel electrode **21** as shown in FIG. **10**.

The shapes of the apertures on the two substrates may be exchanged.

In order to obtain less response time, it is preferable that the apertures on the different substrates are parallel to each other, which is the sixth embodiment shown in FIG. **11**.

A linear aperture **252** extending longitudinally is formed in the center of a pixel electrode on a TFT panel **20**, and two linear longitudinal apertures **251** on a color filter panel **10** are located left and right to the aperture **252**, and thus the apertures on the different substrates are arranged alternately. Polarizing directions **P1** and **P2** are perpendicular to each other and make an angle of 45° with respect to the extension of the apertures **251** and **252**.

In this case, since the liquid crystal molecules in a domain uniformly incline in the same direction, i.e., the direction perpendicular to the aperture, the response time is very fast as about 30 ms. However, in this case, only 2 average axial directions are generated, and the viewing angle is not good compared with the former embodiments.

Another aperture pattern for obtaining fast response time as well as four average axial directions is provided in the seventh embodiment of the present invention shown in FIG. **12**.

FIG. **12** shows two adjacent pixels **310** and **320** and an aperture pattern formed thereon. Apertures **253** and **255** on the upper substrate **10** and apertures **254** and **256** extend obliquely to make an angle with the transverse and the longitudinal directions. The apertures **253**, **254**, **255** and **256** in a pixel **310** and **320** are parallel to each other, and the extensions of the apertures in the adjacent pixels makes an angle such as 90 degrees. In this case, a pair of pixels yields 4 different average axial directions.

Polarizing directions **P1** and **P2** are aligned in the transverse and longitudinal directions.

The disclination that the liquid crystal molecules are disordered may be generated near the intersections of the pixel electrodes and the apertures **254** and **256** on the lower substrate **20**, more exactly, at the portion where the apertures makes an obtuse angle with the pixel electrode. The disclination reduces the luminance of the LCD, and afterimage may be generated since the position of the disclination region varies according to the applied voltage.

FIG. **13**, which illustrate the eighth embodiment of the present invention, shows a branch **257** of the aperture **253** on the color filter substrate, which extends to the point where the boundary of the pixel electrode **21** and the aperture **253** make an obtuse angle along the edges of the pixel electrode **21**. The width of the branch **257** may gradually decrease from the connection with the apertures **253** to the ends. This shape decreases the disclination and increases the luminance.

According to the seventh and the eighth embodiments, two average axial directions exist in a pixel, and four average axial directions in a pair of the pixel regions.

The various arrangement of pixels having different average axial directions are possible, and these embodiments are shown in FIGS. **14** and **15**.

According to the ninth embodiment shown in FIG. **14**, the pixels arranged in the row direction has the same average axial direction, while the adjacent pixels in a column have different average axial directions. In order to make different average axial directions, the oblique angles of apertures is differentiated.

On the contrary, according to the tenth embodiment shown in FIG. **15**, the oblique angles of the apertures of adjacent pixels in a column are different, while, in row direction, the pixels in a dot including red, green and blue pixels has the same average axial direction, and the average axial direction is altered by unit of dot.

According to the embodiments of the present invention, multi-domain LCDs are formed using various aperture pattern to control the arrangement of liquid crystal molecules, therefore wide viewing angle is obtained, disclination is removed and the luminance is increased.

In the drawings and specification, there have been disclosed typical preferred embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

What is claimed is:

1. A liquid crystal display, comprising:

a first substrate;

a first electrode formed on the first substrate and having a plurality of first domain dividers;

a second substrate facing the first substrate; and

a second electrode formed corresponding to the first electrode on the second substrate and having a plurality of second domain dividers;

wherein the first domain dividers and the second domain dividers have a bent portion in plane view.

2. The liquid crystal display of claim **1**, wherein the bent portion forms an obtuse angle.

3. The liquid crystal display of claim **1**, wherein the first domain dividers and the second domain dividers are interleaved with each other.

4. The liquid crystal display of claim **1**, wherein a number of average axial directions of domains defined by the first domain dividers and the second domain dividers is four.

5. The liquid crystal display of claim **1**, wherein either the first domain dividers or the second domain dividers are apertures.

6. A liquid crystal display comprising:

a first substrate;

a first electrode formed on the substrate and having a plurality of first domain dividers;

a second substrate facing the first substrate; and

a second electrode formed corresponding to the first electrode on the second substrate and having a plurality of second domain dividers,

wherein at least one of the second domain dividers comprises a main body and a branch extending from the main body along an edge of the first electrode.

7. The liquid crystal display of claim **6**, wherein a portion of the branch overlaps the second electrode.

8. The liquid crystal display of claim **6**, wherein the main body and the branch form an obtuse angle.

9. The liquid crystal display of claim **6**, wherein either the first domain dividers or the second domain dividers are apertures.

10. A liquid crystal display comprising:

a first substrate having an inner surface and an outer surface;

a first electrode formed on the inner surface of said first substrate and having a plurality of first domain dividers;

a second substrate facing the first substrate and having an inner surface and an outer surface;

a second electrode formed corresponding to the first electrode on the inner surface of the second substrate having a plurality of second domain dividers;

a plurality of domains formed by the first domain dividers and the second domain dividers, wherein the number of average axial directions of liquid crystal in a group of adjacent domains is four;

a first polarizer attached on the outer surface of said first substrate; and

a second polarizer attached on the outer surface of said second substrate,

wherein the average axial direction of each domain is tilted at an angel of 45°±100° with respect to polarizing directions of the first polarizer and the second polarizer.

11. The liquid crystal display of claim **10**, wherein either the first domain dividers or the second domain dividers are apertures.

12. A liquid crystal display, comprising:

a first substrate having a top surface and a bottom surface;

a pixel electrode formed on the top surface of the first substrate and divided into a plurality of portions;

a second substrate having a top surface and a bottom surface;

a common electrode formed on the bottom surface of the second substrate;

a plurality of first domain forming elements, each formed on the bottom surface of the second substrate and formed corresponding to a center of each portion of the pixel electrode; and

a liquid crystal layer sandwiched between the top surface of the first substrate and the bottom surface of the second substrate.

13. The liquid crystal display of claim **12**, further comprising:

a first polarizer film formed on the bottom surface of the first substrate; and

a second polarizer film formed on the top surface of the second substrate,

wherein the first polarizer film and the second polarizer film polarize either in a longitudinal direction and a direction perpendicular to the longitudinal direction, respectively, or the direction perpendicular to the longitudinal direction and the longitudinal direction, respectively.

14. The liquid crystal display of claim **13**, further comprising a first compensation film attached either between the first substrate and the first polarizer film or between the second substrate and the second polarizer film.

15. The liquid crystal display of claim **14**, wherein the first compensation film is a biaxial compensation film.

16. The liquid crystal display of claim **15**, wherein a slow axis of the first compensation film is parallel or perpendicular to the polarizing directions of the first polarizer film and the second polarizer film.

17. The liquid crystal display of claim **14**, further comprising a second compensation film attached either between the first substrate and the first polarizer film or between the second substrate and the second polarizer film, wherein the second compensation film is attached where the first compensation is not attached.

18. The liquid crystal display of claim **17**, wherein the first compensation film and the second compensation film are an a-plate compensation film and a c-plate compensation film, respectively.

19. The liquid crystal display of claim **18**, wherein a slow axis of the a-plate compensation film is in parallel or perpendicular to the polarizing directions of the first polarizer film and the second polarizer film.

20. The liquid crystal display of claim **12**, wherein the first domain forming element is a protrusion or an aperture.

* * * * *

JS 44 (Rev 11/04)

CIVIL COVER SHEET

07-843

The JS-44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. (SEE INSTRUCTIONS ON THE REVERSE OF THE FORM.)

I. (a) PLAINTIFFS
SAMSUNG ELECTRONICS CO., LTD.
(b) County of Residence of First Listed Plaintiff
(EXCEPT IN U.S. PLAINTIFF CASES)

DEFENDANTS
SHARP CORPORATION; SHARP ELECTRONICS CORPORATION; AND SHARP ELECTRONICS MANUFACTURING COMPANY OF AMERICA, INC
County of Residence of First Listed Defendant
(IN U.S. PLAINTIFF CASES ONLY)
NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE LAND INVOLVED

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Attorneys (If Known)

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- ☐ 710 Fair Labor Standards Act
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BANKRUPTCY
- ☐ 422 Appeal 28 USC 158
- ☐ 423 Withdrawal 28 USC 157

PROPERTY RIGHTS
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SOCIAL SECURITY
- ☐ 861 HIA (1395ff)
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FEDERAL TAX SUITS
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OTHER STATUTES
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Brief description of cause: Patent infringement under 35 U.S.C. Sec. 271.

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JURY DEMAND ☐ Yes ☐ No

VIII. RELATED CASE(S) IF ANY (See Instructions) JUDGE DOCKET NUMBER

DATE 12/21/07
SIGNATURE OF ATTORNEY OF RECORD
TYPE NAME OF ATTORNEY
William J. Marsden, Jr.

AO FORM 85 RECEIPT (REV. 9/04)

United States District Court for the District of Delaware

07-843

Civil Action No. ____________________

ACKNOWLEDGMENT
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NOTICE OF AVAILABILITY OF A UNITED STATES MAGISTRATE JUDGE TO EXERCISE JURISDICTION

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